APPENDIX A
TMDL DEFINITION, PURPOSE, AND CALCULATION

TMDL DEFINITION, PURPOSE, AND CALCULATION

TMDL Definition

A TMDL is defined under Section 75-5-103 of the Montana Water Quality Act as follows:

> "Total Maximum Daily Load or TMDL means the sum of the individual waste load allocations for point sources and load allocations for both nonpoint sources and natural background sources established at a level necessary to achieve compliance with applicable surface water quality standards." (75-5-103-32)
>
> "Waste load allocation means the portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources." (75-5-103-34)
>
> "Load allocation means the portion of a receiving water's loading capacity that is allocated to one of its existing or future nonpoint sources or to natural background sources. (75-5-103-14)
>
> "Loading capacity means the mass of a pollutant that a water body can assimilate without a violation of water quality standards. For pollutants that cannot be measured in terms of mass, it means the maximum change that can occur from the best practicable condition in a surface water without causing a violation of the surface water quality standards." (75-5-103-15)

The above can be summarized as follows:

> TMDL = Loading Capacity = SUM(Waste Load Allocations) + SUM (Load Allocations) + Margin of Safety

The margin of safety is typically identified in the TMDL equation to account for uncertainty about the relationship between pollutant loads and receiving water quality, and is particularly important for TMDLs based on narrative versus numeric standards. The margin of safety can be provided implicitly through analytical assumptions or explicitly by reserving a portion of the loading capacity (EPA, 1999).

In the process of developing a TMDL, an attempt is made to define the individual components of the TMDL, at least to a necessary level of detail to assist with water quality planning and restoration. The waste load allocations are typically applied to individual point sources, but can be applied to a category of point sources. The load allocation associated with natural background is a separate category that should be set equal to the existing natural background load for TMDL development purposes since it is generally not the intent of this process to pursue modifications to natural conditions. The remaining load allocation applies to nonpoint sources, and is typically applied to nonpoint source categories to address the overall cumulative effects from a given category and to better identify potential pollutant reductions through similar applications of best management practices. For example, "roads" represents a significant sediment source category within this water quality restoration plan. Although individual roads are identified, load allocations are applied to all roads within a specific drainage.

Because the ultimate goal is to reduce a given pollutant load to a level that will result in meeting water quality standards, allocations are often expressed as needed load reductions or in some cases as source control actions instead of allowable loads (reference EPA guidance). Even the TMDL is sometimes determined as a surrogate that represents a load reduction or control actions expected to result in meeting water quality standards.

The TMDL and associated allocations must also be determined such that water quality standards are satisfied during all applicable seasons. For example, the loading may need to be determined to address low flow conditions, high flow conditions, or possibly both. The TMDL and associated allocations should also include a factor of safety or other appropriate measure to address uncertainties in such things as loading determinations.

The Purpose of the TMDL

By including the above details, the TMDL development provides a framework that can and should be used to help prioritize and direct efforts to restore beneficial uses through water quality improvements. Thus the term *water quality restoration plan* is often used to more effectively describe the document, such as this one, which incorporates the TMDL and its components. The development and overall intent of a water quality restoration plan (plan) and associated TMDL can vary significantly between water bodies and even between pollutants for the same water body. Examples include situations where the information in the plan:

- provides some of the only documentation available to develop a scientifically defensible strategy, with public and local interest input, that revolves around efforts to improve water quality;
- more or less references work already completed or underway to meet restoration goals; and/or
- references documents and other studies geared toward water quality improvements and restoration of beneficial uses as driven by another program such as a Superfund cleanup site.

The process of water quality restoration plan and TMDL development, therefore, helps ensure that at least every impaired water body condition has an identified approach on how restoration can be achieved. People living within the watershed and in a position to help improve water quality can then become involved with efforts to directly improve water quality.

The second and third bullets above refer to the fact that TMDL development can be used to document successful restoration efforts, or can be used to help focus ongoing programmatic efforts in a direction that helps ensure proper consideration of water quality impairments and applicable Montana water quality standards. Much of the Cooke City area is covered under existing state and federal programs, such as Superfund, which address many of the specific TMDL development requirements, often at a level of detail not typically available for the majority of water bodies in Montana. Because of this significant ongoing effort, this plan generally references much of this ongoing work and the information found in associated planning documents.

TMDL Calculations

Where numeric standards based on metals concentrations exist, the total maximum daily load can be calculated as a function of flow and the applicable water quality standard or target where the standard is equal to the water quality restoration target. Throughout this document, flow data is given in cubic feet per second (cfs or ft^3/sec) and concentration data for most pollutants is in micrograms per liter (ug/l), which is the equivalent of parts per billion. The total maximum load can be calculated in lb/day or ug/sec as shown below, with the former providing a daily scale of measure and the latter providing useful loading rates per second for comparison to previous studies in the Cooke City area. The equation identifies the overall loading capacity to the stream, which comprised of the load and waste load allocations as discussed at the beginning of this appendix.

Total Maximum Load in lb/day
(X ug/l) (Y ft^3/sec) (0.00534) = (X)(Y)(0.00534) lb/day

Total Maximum Load in ug/sec
(X ug/l) (Y ft^3/sec) (28.1) = (X)(Y)(28.1) ug/sec

where:
X = the applicable water quality numeric standard (target) in ug/l;
Y = streamflow in cubic feet per second;
(0.00534) and (28.1) = conversion factors

The use of the above equations addresses all seasonal flow variations. Generally, calculations during low flow represent the most sensitive time period for most but not necessarily all pollutant-water body combinations.

For copper, cadmium, lead, and zinc, hardness also needs to be considered for aquatic life standards (Reference WQB-7; Note 12). The chronic aquatic life standard equation for these metals is identified below (WQB-7 also provides the applicable equation for acute aquatic life standards):

(X ug/l) = exp{mc[ln(hardness)] + bc}

where:
X = the water quality standard calculated as a function of hardness
mc = constant that varies by metal; values provided in WQB-7;
bc = constant that varies by metal; values provided in WQB-7;
hardness = hardness value in mg/l $CaCO^3$; use 400 if >400

For aluminum, iron, and manganese, the standard and any applicable targets are not a function of hardness.

In many situations, such as for sediment, it is not practical to calculate a total maximum daily load (TMDL). From a water quality management perspective, it is instead more practical to use a surrogate value for the TMDL. This surrogate value is often based on such things as the conditions reflecting beneficial use support, a yearly versus daily load, or the change to existing conditions (e.g. a percent reduction in load) needed to result in beneficial use support.

APPENDIX B
WATER QUALITY SUMMARIES FOR METALS AND pH
(BY WATERSHED)

DAISY CREEK AND STILLWATER RIVER WATER QUALITY SUMMARY FOR METALS OF CONCERN AND pH

Copper (Cu)

Total recoverable copper concentrations in Daisy Creek at sampling location DC5 range from 346 ug/l to 2850 ug/l. These values are routinely above the chronic and acute standards for aquatic life at high and low flow conditions. The values also routinely exceed the human health standard of 1300 ug/l. Higher concentrations occur during low flow conditions.

The total copper concentration in sediments at DC5 averages 4759 mg/kg based on information from the Maxim website, and is 1878 mg/kg based on more recent data (Camp, Dresser and McKee, 1997). These results are well above concentrations which negatively impact aquatic life (Camp, Dresser & McKee, 1994).

Total recoverable copper concentrations in the Stillwater River at sampling location SW7 range from below detection to 210 ug/l. These values are routinely above the chronic and acute standards for aquatic life at high and low flow conditions. Higher concentrations tend to occur during medium to higher flow conditions at this location. The average total copper concentration in sediments at SW7 is 2140 mg/kg based on information from the Maxim website, and is 1166 mg/kg based on more recent data (Camp, Dresser and McKee, 1997). These results are well above concentrations which negatively impact aquatic life (Camp, Dresser & McKee, 1994).

For the portion of the Stillwater River located above the confluence with Daisy Creek, total recoverable copper concentrations from 13 samples show that 12 samples range from below detection to 4 ug/l, and one sample is reported at 7 ug/l. This 7 ug/l occurred during a higher flow condition when the chronic aquatic life standard would be 6.8 mg/l based on actual measured hardness. MDEQ criteria for a (moderately) impaired water body under conditions such as this (MDEQ Appendix A to the 2000 303(d) List) reads as follows:

> "For any pollutant: Acute standards are exceeded by less than 25%; and/or chronic standards are exceeded by 10-50%; and/or water quality standards are exceeded in no more than 10% of the measurements from a large data set."

None of the above criteria for identifying a stream as being impaired for copper appear to be satisfied. The chronic standard is exceeded less than 10% of the time and only by 3%. This implies that the Stillwater River above Daisy Creek is not impaired for copper, although 13 samples may not constitute a large data set. MDEQ criteria further defines an unimpaired or least impaired water body (i.e. fully supports beneficial uses) as follows:

> "For any pollutant: No exceedence of acute or chronic standards, and/or the chronic standards are exceeded by less than 10% no more than once for one parameter in a three year period when measurements were taken at least four times/year (quarterly)."

The only criteria not met above is the three year quarterly sampling, which is difficult to accomplish given the winter conditions in this area. Nevertheless, sampling during the higher flow events of concern has occurred over several years, and indicates that copper may not be a problem for this stream segment.

Iron (Fe)

Total recoverable iron concentrations in Daisy Creek at sampling location DC5 range from 2380 ug/l to 6880 ug/l. At both higher and lower flow conditions, these values are routinely above the 1000 ug/l chronic acute standard for aquatic life (no hardness adjustments for iron). At both higher and lower flow conditions, the iron values in Daisy Creek are also routinely above the 300 ug/l guidance value for determining levels that will interfere with the specified uses, which is applicable due to the drinking water/domestic water beneficial use associated with a B-1 classification. Higher values occur during lower flow conditions. Precipitation of iron also contributes to objectionable streambed deposits.

Total recoverable iron concentrations in the Stillwater River at sampling location SW7 range from 70 ug/l to 1200 ug/l. These values occasionally are above the 1000 ug/l chronic acute standard for aquatic life and are also routinely above the 300 ug/l guidance value discussed above. Higher values of iron tend to occur during higher flow conditions. Precipitation of iron also contributes to objectionable streambed deposits, generally just downstream from the Daisy Creek confluence.

For the portion of the Stillwater River located above the confluence with Daisy Creek, total recoverable iron concentrations from 13 samples show that 12 samples range from very low values to 270 ug/l, and one sample is reported at 390 ug/l measured at a high flow condition. Iron loading during higher flows from this upper section of the Stillwater River may need to be considered when evaluating the ability to reach high flow cleanup goals at SW7.

Manganese (Mn)

Total recoverable manganese concentrations in Daisy Creek at sampling location DC5 range from 14 ug/l to 1230 ug/l. At both higher and lower flow conditions, these values are routinely above the 50 ug/l guidance value for determining levels that will interfere with the specified uses, which is applicable due to the drinking water/domestic water beneficial use associated with a B-1 classification. Higher values occur during lower flow conditions.

Total recoverable manganese concentrations in the Stillwater River at sampling location SW7 range from below detection to 80 ug/l. These values are often above the 50 ug/l guidance value discussed above. There are not any obvious flow related trends at this sampling location.

Total recoverable manganese concentrations are all below 50 ug/l at a sampling location in the Stillwater River above Daisy Creek.

Aluminum (Al)

Dissolved aluminum concentrations in Daisy Creek at sampling location DC5 range from 40 ug/l to 300 ug/l. Although aluminum values typically range well above the 87 ug/l chronic standard for aquatic life, this standard only applies to a pH range of 6.5 to 9.0. None of the data shows aluminum exceeding 87 ug/l at times when the pH was in this range. Precipitation of aluminum does, however, contribute to objectionable streambed deposits and high turbidity. Higher values occur during lower flow conditions. Total recoverable aluminum concentrations at DC5 range from 1,400 to 8,100 ug/l, which is an indicator of available aluminum for precipitation and resulting turbidity problems.

Dissolved aluminum concentrations in the Stillwater River tend to be low, but the precipitation of aluminum in Daisy Creek contributes to high turbidity and may also contribute to objectionable streambed deposits just below the confluence with Daisy Creek. At SW7, which is further downstream (Figure 1-5) turbidity due to aluminum precipitation does not appear to be a problem during low flow conditions. The total recoverable aluminum concentrations are consistently less than 200 ug/l during these low flow conditions at SW7.

Zinc (Zn)

Total recoverable zinc concentrations in Daisy Creek at sampling location DC5 range from 60 ug/l to 420 ug/l. These values are routinely above the chronic and acute standard for aquatic life at high and low flow conditions. Higher concentrations occur during low flow conditions.

Total recoverable zinc concentrations in the upper and lower portions of the Stillwater do not indicate a water quality impairment problem for this pollutant. The sediment data does indicate fairly high zinc levels in sediment at SW7, although this high level is not consistent with lower upstream sediment levels in both the Stillwater River just below Daisy Creek and within Daisy Creek.

Cadmium (Cd)

Total recoverable cadmium concentrations in Daisy Creek at sampling location DC5 range from less than 1 ug/l to 2.85 ug/l. These values are often above the chronic standards for aquatic life at high and low flow conditions, and sometimes above the acute standards for aquatic life at high and low flow conditions. There is a trend of higher concentrations at lower flow conditions.

Total recoverable cadmium concentrations in the upper and lower portions of the Stillwater River do not indicate a water quality impairment problem for this pollutant.

Lead (Pb)

Total recoverable lead concentrations in Daisy Creek at sampling location DC5 range less than 1 ug/l to 3 ug/l. These values are occasionally above the chronic standards for aquatic life at high and low flow conditions (Table 2-1). Flow related trends are not obvious. The average total lead concentration in sediments at DC5 is 76 mg/kg based on information on the Maxim website, and is 138 mg/kg based on more recent data (Camp, Dresser and McKee, 1997). These results are above concentrations which negatively impact aquatic life (Camp, Dresser and McKee, 1994).

Total recoverable lead concentrations in the upper portions of the Stillwater River and at site SW7, in addition to concentrations of lead in sediment samples, do not consistently indicate a water quality impairment problem for this pollutant. There are some indications that the Stillwater River may be impaired due to lead as measured further upstream. Any such conditions would be addressed via efforts to address lead concerns within Daisy Creek since that is where all the sources of lead have been identified.

pH

The pH values in Daisy Creek at sampling location DC5 range from 5.3 to 7.7. At both higher and lower flow conditions, these values are not consistent with applicable standards based on known acid drainage contributions and anticipated pH values in comparison to natural background conditions. Since pH is influenced by several contaminants and associated water chemistry alterations, the natural background conditions are difficult to predict although many waters in Montana fall within the range of 6.0 to 9.0. Acid mine drainage conditions are a prime source of lowered pH in Daisy Creek and are closely tied to the other metal impairments. There is an apparent trend of lower pH values during lower flow conditions.

Water quality results for pH in the upper and lower portions of the Stillwater River do not indicate a water quality impairment problem for this parameter.

FISHER CREEK AND CLARKS FORK RIVER WATER QUALITY SUMMARY FOR METALS OF CONCERN AND pH

Copper (Cu)

Total recoverable copper concentrations in Fisher Creek at sampling location SW3 range from 30 ug/l to 1530 ug/l, and at SW4 range from below detection to 180 ug/l. These values, particularly at SW3, are consistently above the chronic and acute standards for aquatic life at high and low flow conditions. The highest concentrations occur during the late summer and autumn low flow conditions.

Total recoverable copper concentrations in the Clarks Fork River at sampling location SW6 range from below detection to 70 ug/l. These values are routinely above the chronic and acute standards for aquatic life at high and low flow conditions. There may be a trend of higher concentrations during higher flow conditions at this location.

The total copper concentrations in stream sediments is as high as 1176 mg/kg in Fisher Creek at SW4, and 1162 mg/kg in the Clarks Fork River (Camp, Dresser and McKee, 1997). These results are well above concentrations which negatively impact aquatic life (Camp, Dresser & McKee, 1994).

Iron (Fe)

Total recoverable iron concentrations in Fisher Creek at sampling location SW3 range from 40 ug/l to 11,600 ug/l, and at SW4 range from 30 ug/l to 3170 ug/l. These values are consistently above the 1000 ug/l chronic acute standard for aquatic life (no hardness adjustments for iron) at SW3. At both higher and lower flow conditions, the iron values in Fisher Creek are also routinely above the 300 ug/l guidance value for determining levels that will interfere with the drinking water/domestic water beneficial use associated with a B-1 classification. Higher values tend to occur at lower flow conditions at SW3, but during higher flow conditions at SW4 since much of the iron has precipitated out upstream of SW4 during low flow conditions and is possibly re-suspended during the higher flows. Precipitation of iron also contributes to objectionable streambed deposits.

Total recoverable iron concentrations in the Clarks Fork River do not appear to be consistently high enough to cause an impairment to beneficial uses. There is one historical value of 2,880, but this value is not consistent with multiple other sample results during similar flows and time periods when the data shows iron levels consistently below 300 ug/l.

Manganese (Mn)

Total recoverable manganese concentrations in Fisher Creek at sampling location SW3 range from 160 ug/l to 1670 ug/l, and at SW4 range from less than 10 ug/l to 160 ug/l. At SW3, these values are consistently above the 50 ug/l guidance value for determining levels that will interfere with the specified uses, which is applicable due to the drinking water/domestic water beneficial use associated with a B-1 classification. Higher values tend to occur during lower flow conditions.

Total recoverable manganese concentrations in the Clarks Fork River are not high enough to cause an impairment to beneficial uses.

Aluminum (Al)

Dissolved aluminum concentrations in Fisher Creek at sampling location SW3 range from 1360 ug/l to 5000 ug/l, and at SW4 range from less than 100 ug/l to 1300 ug/l. Some of the values at SW4 exceed the 87 ug/l chronic standard for aquatic life within the pH range of 6.5 to 9.0, whereas the pH is consistently below 6.5 at SW3 when elevated dissolved aluminum values have been detected. Precipitation of aluminum contributes to objectionable streambed deposits and high turbidity at upstream locations where total recoverable aluminum concentrations are also high. Total recoverable aluminum concentrations at SW3 range from 1100 ug/l to 4800 ug/l, and at SW4 range from less than 100 ug/l to 1100 ug/l. This total recoverable aluminum is an indicator of available aluminum for precipitation and resulting turbidity problems. Higher upstream values of aluminum occur during low flow conditions.

Dissolved aluminum concentrations in the Clarks Fork River are not high enough to cause an impairment to beneficial uses, nor does there appear to be a problem with streambed deposits and increased turbidity from aluminum.

Zinc (Zn)

Total recoverable zinc concentrations in Fisher Creek at sampling location SW3 range from 30 to 290 ug/l, and at SW4 range from less than 10 ug/l to 80 ug/l. These values, particularly at SW3, are consistently above the chronic and acute standard for aquatic life at high and low flow conditions. Higher concentrations occur during low flow conditions.

Total recoverable zinc concentrations in the Clarks Fork River at sampling location SW6 range from less than 10 ug/l to 50 ug/l. These values are sometimes just above the chronic and acute standard for aquatic life at high flow (softer water) conditions only.

Cadmium (Cd)

Total recoverable cadmium concentrations in Fisher Creek at sampling location SW3 range from less than 0.1 ug/l to 2.2 ug/l, and at SW4 range from less than 0.1 ug/l to 2 ug/l. These values are often above the chronic standard for aquatic life at high and low flow conditions, and sometimes exceed the acute standard for aquatic life. There is a trend of higher concentrations at lower flow conditions.

Total recoverable cadmium concentrations in the Clarks Fork River at sampling location SW6 are typically below detection, although three detections during high flow conditions (1, 2, and 80 ug/l) exceed both the chronic and acute aquatic life standards for cadmium, and the highest concentration exceeds the human health criteria associated with a drinking water use. It is unknown at this time if the 80 ug/l represents an actual stream concentration or is associated with a lab or sampling error.

Lead (Pb)

Total recoverable lead concentrations in Fisher Creek at sampling location SW3 range from less than 3 ug/l to 9 ug/l, and at SW4 range from less than 1 ug/l to 10 ug/l, often above aquatic life standards. Total recoverable lead concentrations in the Clarks Fork River are not high enough to exceed water quality standards. Sediment data shows elevated levels of lead at concentrations that appear to be harmful to aquatic life in both Fisher Creek and the Clarks Fork River (Camp, Dresser and McKee, 1994 & 1997).

Silver (Ag)

Total recoverable silver concentrations in Fisher Creek at sampling location SW3 range from less than 0.5 ug/l to 1.1 ug/l, and at SW4 range from less than 0.2 ug/l to 9 ug/l. These results represent only a few detections at each location which exceed the acute aquatic life standards. The detections and higher concentrations tend to occur at lower flow conditions.

The Kimball et al. study provides silver sample results along several locations along Fisher Creek and for several tributaries. All sampling was done on August 19, 1997. The results indicate a few locations where silver was found to be slightly above the 4 ug/l detection limit, and therefore greater than the aquatic life support standard.

Total recoverable silver concentrations in the Clarks Fork River at sampling location SW6 range from less than 0.2 to 30 ug/l. These results reflect only two detections, both of which exceed the acute aquatic life standard. It is unknown at this time if the 30 ug/l represents an actual concentration in the stream or is associated with a lab or reporting error, especially since it occurs on the same day as the high cadmium concentration whereas other metal concentrations on this same day are relatively low.

pH

The pH values based on field conditions in Fisher Creek at sampling location SW3 range from 2.9 to 6.6, with most values well below 5.0, and at SW4 range from 5.3 to 7. At both higher and lower flow conditions, these values, particularly at SW3, are not consistent with applicable standards based on known acid drainage contributions and anticipated pH values in comparison to natural background conditions. Since pH is influenced by several contaminants and associated water chemistry alterations, the natural background conditions are difficult to predict although most waters in Montana fall within the range of 6.0 to 9.0. Acid mine drainage conditions are a prime source of lowered pH in Fisher Creek and are closely tied to the other metal impairments. There is an apparent trend of lower pH values during lower flow conditions.

Water quality results for pH in the Clarks Fork River also indicate a possible problem, with values ranging from 4.8 to 9.4. Not many pH values are below 6.0, and they tend to occur during higher flow periods.

MILLER CREEK AND SODA BUTTE CREEK WATER QUALITY SUMMARY FOR METALS OF CONCERN

Copper (Cu)

Total recoverable copper concentrations in Miller Creek at sampling location SW5 range from 1 ug/l to 200 ug/l. These values are often above the chronic and acute aquatic life support standards, generally during higher flow conditions. Except for two sample events, all copper values are less than 30 ug/l. These two sample events occurred during two of the four highest sampled flows at SW5. Both high sample results are supported by similar high sample results at upstream location SW2 collected during the same day. Both sampling events were within two weeks of each other during June 1990.

Sediment data for Miller Creek consistently shows high levels of copper up to approximately 540 mg/kg. These results are above concentrations which negatively impact aquatic life (Camp, Dresser, McKee, 1994).

Total recoverable and dissolved copper concentrations in Soda Butte Creek are typically at levels below standards. Some of the dissolved copper data from Nimmo et al (1999) are at higher levels (up to 9 ug/l) than the Montana Water Quality Standards in WQB-7, which are based on total recoverable metals. Values of total recoverable metals should always be as high or higher than dissolved metals values. Therefore, if a dissolved concentration exceeds the standard, then it can be assumed that the total recoverable concentration would also exceed the standard. Higher copper values seem to occur during higher flow periods when the copper is more of a concern due to lower water hardness and a lower applicable standard.

The USGS data near SBC4 (USGS, 2001) for the 1999 through 2000 period show total recoverable copper values ranging from below 10 ug/l to 22.4 ug/l at high flows, and one value at 11 ug/l during winter low flow. The use of relatively high detection levels for total recoverable copper makes it difficult to fully evaluate this data and the USGS synoptic data with respect to Montana's water quality standards.

The Maxim website information shows that total recoverable copper levels all along Soda Butte Creek commonly range from 1 to 8 ug/l, with at least one concentration and hardness combinations leading to conditions where the aquatic life support standard is exceeded. It is worth noting that there is limited high flow data in comparison to the USGS data discussed above.

Sediment data for Soda Butte Creek indicates a copper problem, with sediment levels as high as 1200 mg/kg downstream or adjacent to the McLaren Tailings (Nimmo, et. al, 1999). Other studies with limited numbers of in-stream sediment samples in this vicinity have resulted in values below 300 mg/kg (Pioneer, 2001a), some or all of which may be below levels of concern (Camp, Dresser and McKee, 1994)

Iron (Fe)

Total recoverable iron concentrations in Miller Creek at sampling location SW5 range from 30 to 3220 ug/l. These values are consistently above the 1000 ug/l chronic acute standard for aquatic life (no hardness adjustments for iron) during high flow periods only. These high flow values are also routinely above the 300 ug/l guidance value for determining levels that would interfere with the drinking water/domestic water beneficial use associated with a B-1 classification.

Total recoverable iron concentrations in Soda Butte Creek at sampling location SBC-2 or in the vicinity have ranged from 460 ug/l to 3160 ug/l. These values are routinely above the 1000 ug/l chronic standard for aquatic life during low flow periods and above the 300 ug/l drinking water/domestic use support level. Precipitation of iron also contributes to objectionable streambed deposits downstream from the McLaren Tailings during these same low flow periods. There is a lack of data in this location for high flow periods such as those that cause very high iron values in Miller Creek (discussed above) and further downstream in Soda Butte Creek (discussed below).

At sampling location SBC-4, which is just upstream of Yellowstone National Park, the total recoverable iron values range from 150 ug/l to 6260 ug/l. These values are sometimes above the 1000 ug/l acute aquatic life standard during higher flow periods. The values are also routinely above the 300 ug/l guidance value for determining levels that will interfere with drinking water/domestic use associated with a B-1 or A-1 stream classification.

Manganese (Mn)

Total recoverable manganese concentrations in Miller Creek at sampling location SW5 range from less than 10 ug/l to 130 ug/l. At high flow conditions, the values are routinely above the 50 ug/l guidance value for determining levels that will interfere with the specified uses, which is applicable due to the drinking water/domestic water beneficial use associated with a B-1 classification.

Total recoverable manganese concentrations in Soda Butte Creek at sampling location SBC-2 range from less than 10 ug/l to 160 ug/l. These values are consistently above the 50 ug/l standard discussed above. Manganese values at SBC-4 are below 50 ug/l, except at the highest measured flows when values can be as high as 210 ug/l.

Zinc (Zn)

Total recoverable zinc concentrations in Miller Creek at sampling location SW5 range from less than 10 ug/l to 460 ug/l. There are only three values out of 28 at levels above the applicable standard. Upstream at SW2, only one value out of t 23 is above the applicable standard. This value is 190 ug/l. It is difficult to identify a flow-related trend.

Zinc results indicate that this metal is not a beneficial use problem in Soda Butte Creek, and therefore a zinc TMDL is not developed for this water body.

Cadmium (Cd)

Total recoverable cadmium concentrations in Miller Creek at sampling location SW5 range from less than 0.1 ug/l to 0.4 ug/l. There are only a few values that are greater than the chronic standard for aquatic life, and these only occur at the highest flows.

Cadmium results indicate that this metal is not a beneficial use problem in Soda Butte Creek, and therefore a cadmium TMDL is not developed for this water body, although the McLaren Tailings is contributing cadmium to Soda Butte Creek at elevated levels (Boughton, 2001).

Lead (Pb)

Total recoverable lead concentrations in Miller Creek at sampling location SW5 range from less than 2 ug/l to 22 ug/l. There are only a few values that are greater than the aquatic life standards, and these tend to occur at the higher flows. One value is also greater than the human health standard of 15 ug/l. Sediment data from two different sources show elevated lead levels above 85 mg/kg (Personal communication with Tom Cleasby; Camp, Dresser and McKee, 1997). These results are above concentrations which negatively impact aquatic life (Camp, Dresser, McKee, 1994).

Total recoverable lead concentrations in Soda Butte Creek at sampling location SBC4 range from below detection to 13 ug/l with one value at 58 ug/l. There are only a few values that are greater than the aquatic life or human health standards, and these all occur at high flows. At sampling location SBC2, lead values tend to be below detection except for one value at 2 ug/l, which is less than the aquatic life standards given hardness values on that same day, indicating that lead may not be a significant problem under low flow conditions. Nevertheless, the McLaren Tailings are contributing lead to Soda Butte Creek at elevated levels (Boughton, 2001), which possibly contribute to elevated lead levels in stream sediments.

Aluminum (Al)

Total recoverable aluminum concentrations in Miller Creek at sampling location SW5 range from 200 ug/l to 1800 ug/l. Corresponding dissolved aluminum data is not available during these high flows. Therefore, it is difficult to know if the 87 ug/l chronic standard for aquatic life, which is based on dissolved aluminum within a given pH range, has been exceeded or not.

Dissolved aluminum values are typically low in Soda Butte Creek near sample locations SBC2 and SBC4. During very high flow events, total recoverable aluminum values from the USGS gaging station data located at or near SBC4 are as high as 4640 ug/l, although the corresponding dissolved aluminum values are all low (<18 ug/l). There is one value of high dissolved aluminum (200 ug/l) from 1994 sampling at SBC4. The synoptic sample results (Boughton, 2001) show several stream reaches between Woody Creek and Yellowstone National Park where there are elevated dissolved aluminum levels, with one value as high as 163 ug/l. Both the 163 and 200 ug/l values are above the standard given the corresponding pH levels

APPENDIX C

DISCUSSION, SUMMARY AND CONCLUSIONS FOR DAISY CREEK AND STILLWATER RIVER METALS SOURCES (EXCERPT FROM NIMICK AND CLEASBY, 2001)

METAL SOURCES

Copper is the metal of most concern in Daisy Creek because it occurs at higher concentrations than other metals and can be toxic to aquatic life. Therefore, sources of copper loading are discussed in this section. The sources of the other metals in Daisy Creek, with the occasional exception of lead, are thought to be the same as copper. The magnitude and source of copper loads contributed to subreaches of Daisy Creek from surface and subsurface inflows are presented in table 2.

Copper loading to Daisy Creek was substantial in the reach upstream of mainstem site 5,475 (fig. 15). This reach can be divided into five subreaches on the basis of the different source areas that contribute copper to Daisy Creek (table 2). Dissolved copper loads are discussed here because, in this reach, almost all of the copper load is dissolved. Sources of copper included right-bank surface inflows and subsurface inflow. Left-bank inflows contributed less than 0.02 percent of the entire copper load in this reach.

The upstream subreach (between sites 0 and 270) flows past a small, right-bank hill composed of landslide or glacial-moraine deposits. This subreach had minor copper loading (461 µg/s) from an inflow on the south side of the hill (inflow site 74) and from streamside seeps at its base (inflow sites 114 and 161). Subsurface inflow also contributed a small copper load (151 µg/s) to Daisy Creek (table 2).

The second subreach (between sites 270 and 460) received a substantial copper load (10,100 µg/s). Most of this load came from the four right-bank surface inflows (sites 292, 348, 401, and 411) that originate in the manganese bog adjacent to Daisy Creek. Copper loading from subsurface inflow was small (251 µg/s).

In the third subreach (between sites 460 and 611), one right-bank inflow (site 481), enters Daisy Creek and contributed more copper (16,400 µg/s) to Daisy Creek than all other surface inflows combined (table 7). This inflow drains the southern part of the McLaren Mine (fig. 2), where much of the mine wastes are stockpiled and where substantial unmined mineralized rock remains. Unlike the two upstream subreaches, copper loading from subsurface inflow (8,900 µg/s) in this part of Daisy Creek was substantial.

In the fourth subreach (between mainstem site 611 and inflow site 1,700), subsurface inflow contributed almost all the copper loading (7,040 µg/s). The most prominent right-bank inflows (sites 691 and 1,700, which drain the northern part of the McLaren Mine) contributed only 143 µg/s (table 7). The copper loading from these two sites and the other four right-bank inflows was only 245 µg/s. Although inflow site 1,700 was not a significant source of copper to Daisy Creek, the inflow did contribute a relatively large load of dissolved lead (6.11 µg/s), almost as high as the load contributed by inflow site 481 (7.45 µg/s, table 7).

The fifth, and most downstream, subreach (between sites 1,700 and 5,475) is the longest of the five subreaches. Surface inflows to this subreach do not drain the McLaren Mine. Copper loading from surface inflows was negligible (2 µg/s) while subsurface loading (6,210 µg/s) was relatively large, although smaller than in the two previous upstream subreaches.

Table 2. Sources of dissolved copper to subreaches of Daisy Creek, Montana, August 26, 1999

[Values listed for loads have been rounded. Abbreviations: µg/s, micrograms per second. Symbol: <, less than]

Subreach description[1]	Subreach extent		Dissolved copper load (µg/s)			
	Upstream site	Downstream site	Right-bank inflows	Left-bank inflows	Subsurface inflow[2]	Combined surface plus subsurface
Moraine or landslide hill	0	270	461	<1	151	612
Manganese bog	270	460	9,830	4	251	10,100
Southern part of McLaren Mine area	460	611	16,400	4	8,900	25,300
Northern part of McLaren Mine area	611	1,700	245	<1	7,040	7,290
Area north and west of McLaren Mine	1,700	5,475	2	<1	6,210	6,210
TOTAL			26,900	8	22,600	49,500

[1]Describes area from which metal-rich surface drainage to subreach is derived.

[2]Calculated as the difference between the gain in instream load between upstream and downstream sites and the sum of the loads in the right-bank and left-bank inflows within the subreach.

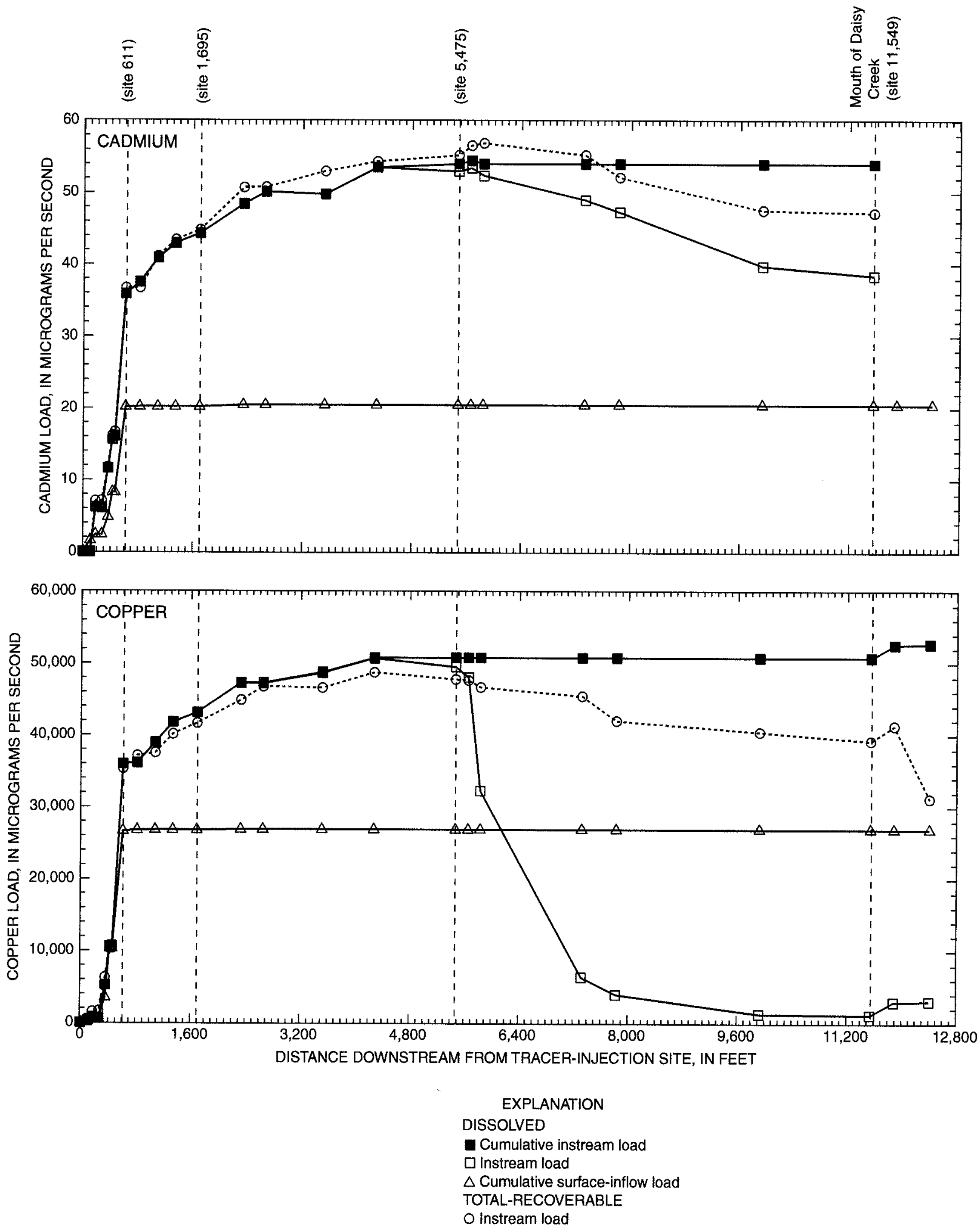

Figure 15. Downstream profiles of cadmium (top) and copper (bottom) loads in Daisy Creek and the Stillwater River, Montana, August 26, 1999.

In summary, the most substantial copper loading to Daisy Creek (71 percent of the total copper load contributed to the entire study reach) occurred between sites 270 and 611, where right-bank inflows originate in the manganese bog and the southern part of the McLaren Mine. About 53 percent of the total load in the study reach was contributed by the five right-bank inflows in this 341-ft reach, with inflow site 481 (33 percent of the total) being the most important. Copper loading to Daisy Creek from all surface inflows downstream from mainstem site 611, including the surface inflows that drain the northern part of the McLaren Mine, was not significant, at least during the low-flow conditions that existed during this study. While surface inflows contributed the most copper to Daisy Creek upstream of site 611, subsurface loading was the only important source of copper for the longer downstream reach between sites 611 and 5,475. Subsurface loading in this reach contributed over half of the total subsurface loading to Daisy Creek and 27 percent of the total load to Daisy Creek.

Although the subsurface inflow to Daisy Creek was not sampled, copper concentrations in the subsurface inflow (table 3) can be calculated from the subsurface inflow rates and copper loads contributed by subsurface inflow. These calculations assumed that one-half of the subsurface inflow came from the right bank and was metal rich; the subsurface inflow from the left bank was assumed to contribute no copper load to Daisy Creek. For the reach between sites 460 and 611, the calculated dissolved copper concentration (26,200 µg/L) in subsurface inflow from the right bank is similar to the concentration in some of the nearby right-bank inflows (for example, sites 292, 348, and 401), indicating that the subsurface pathway feeds both the right-bank surface and subsurface inflows. Calculated copper concentrations for subsurface inflow between sites 611 and 5,475 were lower, but substantially higher than concentrations in surface inflows in that reach. The pH and copper concentrations in the subsurface flow vary spatially, most likely in response to the varying amounts of alteration and buffering capacity in the rocks along different subsurface flow paths, as well as to dilution provided by any deeper ground water flowing from areas of unaltered bedrock.

Much of the metal-rich subsurface inflow to Daisy Creek probably was acidic. Although pH was not measured in subsurface flow, this hypothesis is supported by the presence of dissolved aluminum in the subsurface inflow. Aluminum is only likely to be dissolved where the pH is less than about 4.5 (Stumm and Morgan, 1996, p. 273).

The copper load entering Daisy Creek between sites 270 and 1,700 as surface and subsurface inflow is derived from the McLaren Mine area. Although this copper load has been divided between surface and subsurface inflows (table 2), in reality virtually none of this load comes directly from the McLaren Mine to Daisy Creek as surface flow. Almost all of the right-bank channels (except site 1,700) were dry from the McLaren Mine area to within a short distance of Daisy Creek. Flow in these short reaches near Daisy Creek was maintained by subsurface inflow. Determining the source of the subsurface inflow to Daisy Creek and

Table 3. Calculated concentrations of dissolved copper in subsurface inflow to subreaches of Daisy Creek, Montana, August 26, 1999

[Abbreviations: L/s, liters per second; µg/L, micrograms per liter; µg/s, micrograms per second]

Subreach description[1]	Subreach extent		Subsurface inflow		
	Upstream site	Downstream site	Flow[2] (L/s)	Dissolved copper load[3] (µg/s)	Calculated dissolved-copper concentration[4] (µg/L)
Moraine or landslide hill	0	270	0.40	151	755
Manganese bog	270	460	.21	251	2,390
Southern part of McLaren Mine area	460	611	.68	8,900	26,200
Northern part of McLaren Mine area	611	1,700	1.63	7,040	8,640
Area north and west of McLaren Mine	1,700	5,475	3.12	6,210	3,980

22,552 subsurface

[1]Describes area from which metal-rich surface drainage to subreach is derived.
[2]Calculated from data in table 5.
[3]Data from table 2.
[4]Concentrations are for right-bank surface inflows. Assumes that one-half of subsurface inflow came from right side of Daisy Creek and that subsurface inflow from left side of Daisy Creek contributes no copper load.

inflow channels is difficult because several possible sources exist within the McLaren Mine area. These sources include the mineralized rocks of Fisher Mountain upgradient of the McLaren Mine area, the surficial waste rock at the mine, and the underlying bedrock, which hosts both the McLaren ore deposit and the surrounding altered rock that is pyritic. More detailed hydrogeologic information would be needed to determine the importance of each of these sources.

The occurrence of metal-rich subsurface inflow to Daisy Creek upstream and downstream from the tributaries that drain the McLaren Mine area indicates that bedrock to the south and north of the McLaren Mine area apparently is a source of acid rock drainage not related to mining. The small subsurface metal load that discharges to Daisy Creek upstream of site 104 may be derived from the Chimney Rock area (fig. 1). The larger subsurface metal load that discharges to Daisy Creek downstream from site 1,700 may be derived from Fisher Mountain. The ferricrete deposits mapped by Furniss and others (1999) near site 2,334 and dated as 6,490 radiocarbon years before present support the hypothesis that unmined bedrock is one of the current sources of metals to Daisy Creek. However, this subsurface flow has not been directly measured. Monitoring well MW-3 (fig. 2) presumably should intercept this subsurface flow, but water-quality data for samples collected from the well do not support this hypothesis. This shallow well is completed in unconsolidated surficial material and the Wolsey Shale with a screen that extends from 16 to 46 ft below ground surface (Hydrometrics, Inc., 1990). Five samples collected during 1989-90 had pH values greater than 7 and low dissolved-metal concentrations. Cadmium, copper, and lead concentrations were at or less than minimum reporting levels (Michael Cormier, Maxim Technologies, Inc., written commun., 1999). Manganese (230-380 µg/L) and zinc (10-100 µg/L) concentrations were higher than minimum reporting levels but much lower than would be expected if ground water at this site were affected by acid rock drainage.

Cleanup activities that reduce metal and acid loading from the McLaren Mine area will result in improvements in water quality in Daisy Creek and the Stillwater River. Metal concentrations likely would decrease, and pH values in reaches that are currently acidic likely would increase. However, potential reductions in metal and acid loading and changes in pH and metal concentrations are difficult to predict because the ultimate source of the metals and acid are not well defined. In addition, decreasing copper concentrations during baseflow conditions to values less than the aquatic-life standards may be impossible because of natural sources of copper in unmined mineralized and altered bedrock. If the assumptions are made that all copper loading upstream of site 1,700 comes from sources at the McLaren Mine and that these sources can be removed or isolated, the copper load (6,210 µg/s, table 2) contributed by subsurface inflow derived from bedrock away from the mine between sites 1,700 and 5,475 would result in a copper concentration in Daisy Creek of about 450 µg/L at site 5,475 compared to the 3,570 µg/L measured in this study (table 6). Because the assumed cleanup activities likely would substantially reduce acid loading, thereby resulting in higher pH values, iron and aluminum colloids would be present and some copper likely would be adsorbed to this material. Therefore, this calculated copper concentration represents a total-recoverable concentration; the dissolved copper concentration would be lower. Downstream, at the mouth of Daisy Creek (site 11,549), the estimated total-recoverable copper concentration would be about 190 µg/L under base-flow conditions compared to the 1,200 µg/L measured during this study. Both calculated copper concentrations are higher than the acute aquatic-life standard of 13 µg/L (assuming a hardness of 100 mg/L, U.S. Environmental Protection Agency, 1999). Farther downstream, the maximum total-recoverable copper concentration in the Stillwater River at the end of the study reach (site 12,410) would be about 35 µg/L compared to the 176 µg/L measured in this study. These calculated copper concentrations are based on the copper loading and streamflow conditions that existed during the short period during which this study was conducted. Concentrations would vary to an unknown degree as hydrologic conditions in the drainage basin changed.

The toxicity of copper (and other metals) is dependent on the hardness of the water. If the metals load in Daisy Creek were reduced, hardness values also would be lower because the right-bank and subsurface inflows contributing metals also contribute calcium and magnesium. Therefore, in considering post-cleanup hardness values to use to compute aquatic-life standards, the values in left-bank inflows (generally less than 100 mg/L) or the Stillwater River (58 mg/L) may represent potential post-cleanup values.

SUMMARY AND CONCLUSIONS

A metal-loading study was conducted during August 24-27, 1999, to quantify and identify the principal sources of metal loads to Daisy Creek and to examine the downstream transport of these metals into the Stillwater River. Water-quality and aquatic conditions in Daisy Creek have been affected by acid rock drainage derived from waste rock and adit discharge at the McLaren Mine as well as from natural weathering of pyrite-rich altered and mineralized rock that makes up and surrounds the ore zones in the New World Mining District. Knowledge of the main sources and transport pathways of metals and acid can aid resource managers in planning and conducting effective and cost-efficient remediation activities.

The study reach included virtually all of Daisy Creek and a 850-ft reach of the Stillwater River downstream from the confluence of Daisy Creek. Metal loads in the mainstem were quantified from streamflow data determined by tracer injection and water-quality data determined from synoptic samples. Loads contributed by surface inflows were determined from these data as well as supplemental streamflow measurements made using conventional methods. Downstream changes in metal loads in the stream then were attributed to sources along the stream as well as to instream geochemical reactions. These sources included visible surface inflows and diffuse subsurface inflows.

The metals cadmium, copper, lead, and zinc have concentrations sufficiently elevated to be of concern for aquatic life in Daisy Creek and the Stillwater River. Copper is the most important of these toxic metals, with a maximum dissolved concentration of nearly 5,800 mg/L measured in Daisy Creek during this study. Metal concentrations increased sharply in the short reach between the tracer-injection site and a site 611 ft downstream, where the highest concentrations measured in Daisy Creek occurred. Acidic, right-bank (mined side) inflows in this reach had dissolved concentrations as high as 20.6 μg/L cadmium, 26,900 μg/L copper, 76.4 μg/L lead, and 3,000 μg/L zinc. These inflows resulted in maximum dissolved concentrations in Daisy Creek of 5.8 μg/L cadmium, 5,790 μg/L copper, 3.8 μg/L lead, and 848 μg/L zinc. Left-bank inflows in this upstream reach consistently had low concentrations (<1 μg/L cadmium, <21 μg/L copper, <1 lead, and <4 μg/L zinc), similar to the values in Daisy Creek at the tracer-injection site. Downstream from mainstem site 611, concentrations of metals decreased to the end of the study reach.

Significant copper loading to Daisy Creek only occurred in the reach upstream of mainstem site 5,475. Sources included right-bank surface inflows and subsurface inflow; copper loads in left-bank surface inflows were virtually nonexistent. The most significant metal loading (71 percent of the total copper loading in the study reach) occurred between mainstem sites 270 and 611. About 53 percent of the total load was contributed by the five right-bank inflows in this reach. Four of these inflows drain the manganese bog that is on the right bank between mainstem sites 270 and 460. Just downstream, inflow site 481, which heads in the southern part of the McLaren Mine, contributed the single largest amount of copper, or about 33 percent of the total copper load in the study reach.

Copper loading from subsurface inflow is substantial, contributing 46 percent of the total dissolved copper load to Daisy Creek. Most of this subsurface copper loading occurred in the reach of Daisy Creek downstream from the reach that received surface loading.

Flow through the shallow subsurface is an important copper-transport pathway from the McLaren Mine and surrounding altered and mineralized bedrock to Daisy Creek during base-flow conditions. The pH and metal concentrations in the subsurface flow probably varied in response to the varying amounts of alteration and buffering capacity in the rocks along different subsurface flow paths. Unfortunately, little is known about the source of acid and copper in this subsurface flow. Possible sources include the mineralized rocks of Fisher Mountain upgradient of the McLaren Mine area, the surficial waste rock at the mine, and the underlying bedrock, which hosts both the McLaren ore deposit and the surrounding altered rock.

APPENDIX D

HIGH AND LOW FLOW WATER QUALITY DATA USED FOR ESTIMATING TMDLS AND LOAD REDUCTION REQUIREMENTS FOR EACH WATER BODY

TABLE D-1: DAISY CREEK HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS (SAMPLE LOCATION DC5)

DC5 High Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
07/13/1995	30	E 485	E 3800	180	2000	< 100	62	0.5	3	6.5
06/18/1996	31	346	3120	143	1400	< 100	60	0.4	E 3	5.8
07/08/1999	24	310	1540	124	1200		70	0.4	1	7.7

DC5 Low Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
10/03/1989	0.37	2540	6880	1160			400	3	1	5.2
09/23/1993	0.54	2170	4680	1200	5300		360	2.3	2	5.8
08/25/1994	0.24	E 2850	E 5700	1230	8100	40	420	2.7	2	5.6
09/27/1995	0.42	2450	2380	1180	7700	100	391	2.3	3	5.4
09/10/1996	0.312	2620	4420	1080	7200	300	370	2.3	< 3	5.4
08/26/1999	1.1	1300	3700	564	4330	18	198	1.5	1.4	7.9

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-2: STILLWATER RIVER HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS (SAMPLE LOCATION SW7)

SW7 High Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese
07/03/1990	123	110	780	50
06/06/1991	158	65	780	35
07/13/1995	113	98	970	50
06/18/1996	223	87	1050	46

SW7 Low Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese
09/25/1990	2.2	20	140	50
08/13/1991	4.1	34	150	70
09/22/1992	8.2	39	150	80
09/23/1993	3.7	60	290	70
08/25/1994	1.7	7	160	27
09/27/1995	2.8	21	170	30
09/10/1996	2.1	19	130	23

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-3: FISHER CREEK HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS (SAMPLE LOCATION SW3)

SW3 High Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
06/27/1990	18	419	5890	160	1700		40	0.1	4	4.8
06/05/1991	7	390	3780	160	1100		30	0.1	2	3.5
06/14/1994	5.42	540	5000	290	2600	1800	58	0.3	7	3.8
07/14/1995	7.29	766	3320	410	2500	2400	76	0.4	8	3.3
07/11/1996	9.18	448	1930	163	1300	1400	40	0.1	<3	4.1

SW3 Low Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
10/20/1989	0.26	850	5590	1230	3700		170	<1	<10	3.4
09/25/1990	0.4	960	6980	1290	3300		160	0.9	7	4.5
09/24/1991	0.2	950	5510	1260	4300	4000	160	2.2	6	3.3
09/21/1993	0.38	1100	11600	1670	3800	3800	170	1	9	3.5
09/27/1995	0.31	1530	11000	1660	4800	5000	231	0.9	8	3.6
09/11/1996	0.38	1040	6910	1320	3500	3800	180	E 0.9	8	3.6

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-4: FISHER CREEK HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS (SAMPLE LOCATION SW4)

SW4 High Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
07/03/1990	83.9	80	650	40	400		20	2	10	9.1
06/05/1991	55.3	E 60	610	30	100		< 10	< 0.1	2	7.1
05/27/1992	77.8	51	310	30	200	200	20	< 0.1	< 2	7.7
05/26/1994	75.2	110	2250	60	800	< 100	18	0.1	3	8.4
06/19/1996	72.2	64	370	36	200	< 100	< 10	< 0.1	< 3	7.8

SW4 Low Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
09/15/1989	1.35	90	90	70	200		70	< 1	< 10	
09/25/1990	1.5	110	210	130	300		50	0.3	< 2	5
09/24/1991	1.1	110	240	80	300	< 100	40	0.6	< 2	6.7
09/23/1992	1.95	117	170	130	300	< 100	50	0.4	< 2	7
09/21/1993	1.98	100	320	160	200	< 100	38	0.2	< 2	7
09/27/1995	1.34	173	90	120	200	< 100	80	0.3	< 2	6.7
09/11/1996	1.46	154	170	150	400	< 100	60	E 0.3	< 3	6.4

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-5: CLARKS FORK OF THE YELLOWSTONE RIVER HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS (SAMPLE LOCATION SW6)

SW6 High Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
06/26/1990	252	37	400	20	200		20	< 0.1	< 2	8.5
06/05/1991	202	17	180	< 20	200		< 10	< 0.1	< 2	6.7
06/15/1994	88	E16	110	10	100	< 100	E 5	< 0.1	< 2	8.3
07/10/1996	149	24	10	13	E 100	E 100	< 10	0.1	< 3	5.4

SW6 Low Flow Data (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
10/20/1989	4.5	< 10	< 30	< 20	< 100		10	< 1	< 10	6
09/25/1990	3.3	7	< 30	< 20	< 100		40	< 0.1	< 2	5.5
08/14/1991	3.9	11	60	< 20	< 100		20	< 0.1	< 2	7.3
09/23/1992	3.5	16	200	20	< 100	< 100	50	0.1	< 2	6.4
09/22/1993	4.2	19	30	30	< 100	< 100	E 18	0.1	< 2	7.2
09/11/1996	2.91	11	20	7	< 100	< 100	E 10	E 0.1	< 3	6.6

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-6: MILLER CREEK HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS

SW5 High Flow (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
06/26/1990	90	153	3220	130	1400	-	40	0.4	22	8.8
06/05/1991	51	E9	3120	110	1800	-	10	0.4	3	7.6
05/27/1992	38	29	540	20	200	100	20	<0.1	< 2	8.1

SW5 Medium Flow (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Zinc	Cadmium	Lead	pH
05/29/1990	14.3	19	340	< 20	200	-	20	< 0.1	3	7
07/09/1991	11.1	21	60	< 20	<100	-	20	< 0.1	-	8.4
07/18/1992	5.5	6	70	< 20	<100	< 100	130	< 0.1	< 2	7.6
07/21/1993	7.6	9	<30	< 10	<100	< 100	E6	< 0.1	< 2	7.4
06/16/1994	9.4	6	40	< 10	<100	< 100	7	< 0.1	< 2	7.4

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

TABLE D-7: SODA BUTTE CREEK HIGH AND LOW FLOW REPRESENTATIVE SAMPLE RESULTS

SBC2 Low Flow (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Cadmium	Lead
07/27/1990	0.02	2	780	30	<100	<100	<0.1	<2
09/24/1991	1.5	E 9	1920	100	100	<100	0.2	2
10/10/2000	0.82	<1	E 2330	110	100		<0.1	<3

SBC4 High Flow (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Cadmium	Lead
06/16/1994	139	E 2	480	10	200	200	<0.1	<2
06/22/1999	504	22.4	6260	210	4640	15	<1	13
07/08/1999	278	3	580	6	400		<0.1	<1
06/07/2000	632	20.7	5200	155	3880	12	<0.11	8
07/07/2000	133	5	E 380	E 10	E 200		<0.1	58

SBC4 Low Flow (flow is measured in cfs, all metals values are ug/l and total recoverable unless otherwise noted)

Date	Flow	Copper	Iron	Manganese	Alum	Alum(diss)	Cadmium	Lead
09/23/1992	14	<1	310	<20	<100	<100	<0.1	<2
09/23/1993	13	3	150	<10	<100	<100	<0.1	<2
09/30/1999	12	<1	150	<5	<100		<0.1	<1
10/10/2000	7	<1	E 410	<20	200		<0.1	<3

High flow data is from representative sample results during spring and early summer runoff. Low flow data is from representative sample from fall or late summer periods. One representative high and low flow sample was typically chosen for every year that such data was available, with preference toward those samples with data for all or most metals of concern.

A value with the > (less than) sign in front of it means that it is less than the detection limit. One half the detection limit was used where average (mean) concentrations were computed for percent reduction calculations. A value with an E in front of it means that it is based on a lab estimate.

APPENDIX E

DISCUSSION AND SUMMARY FOR FISHER CREEK METALS SOURCES (EXCERPT FROM KIMBALL, ET AL., 1999)

Loads of Metals

Patterns of metal loads from mine drainage were more comparable to SO_4 than to Ca because of the substantial number of dispersed subsurface inflows and the reactive chemistry that affected their transport. The extent of chemical reaction was greatest for Fe, but also significant for Al, Cu, Mn, and Zn.

Iron

Thermodynamically, Fe should readily precipitate within the pH range of Fisher Creek to form colloidal-sized, hydrous Fe oxide solids (Lindsay, 1979; Pankow, 1991). Through a sequence that includes precipitation to form nanometer-sized particles, aggregation to form micrometer-sized particles, settling of aggregated colloids, and entrapment by biofilm on cobbles, these colloidal Fe solids coat the streambed of Fisher Creek (Grundl and Delwiche, 1993). Many streams affected by mine drainage have a characteristic ochre-colored streambed from this process. This pattern of Fe loss has been documented in St. Kevin Gulch, Colorado, where a rate constant for the first-order removal of Fe was determined (Kimball and others, 1994). Accumulation of Fe precipitate on the streambed can affect the physical habitat of aquatic organisms and also can create a source of chronic toxicity because of the metals that readily sorb to the Fe colloids.

The mass-load profile of filtered Fe was very different from the profiles of Ca, SO_4, and the other filtered metals (fig. 14a). Because of the reactive behavior of Fe, it is very difficult to account for the total inflow of Fe. It is possible that Fe was removed fast enough to cause a net loss in almost every segment of the stream; there were few positive values of ΔM_S (fig. 14b). Thus, the actual amount of Fe lost from streamwater could have been greater than the difference between the cumulative total load and the sampled instream load might indicate (fig. 14).

Steps in the removal of Fe from the stream are illustrated by looking at the load profiles of Fe(II), filtered, and total-recoverable Fe (fig. 14). First, the Glengary adit and FCT-11 were two large point sources of Fe to the stream at about 300 m. As this large input of Fe was transported downstream, Fe(III) precipitated in the water column as Fe colloids, aggregated, and settled from the stream or was entrapped by biofilm. This results in the continuous decrease in filtered and total-recoverable Fe loads. The nearly constant difference between these two loads, continuing for about 1,000 m of the stream, indicates a constant process of precipitation, aggregation, and removal. With the pH change downstream from 1,750 m and an increase of Fe load, the formation of Fe colloids accelerated. More colloidal Fe was in the water column, as indicated by a greater difference between filtered Fe and total-recoverable Fe loads. The rate of settling, however, did not seem to change because there was little change in the decrease of total-recoverable Fe load with distance. As the filtered Fe load reached the level of the Fe(II) load, the Fe(II) decreased along with the filtered Fe, possibly indicating that Fe(II) was converted to Fe(III) and then precipitated as Fe colloids.

Fe-rich colloids that settle to the streambed or are trapped by algae on streambed cobbles, are flushed by snowmelt runoff the following year. This was the likely cause of large increases in colloidal loads of metals in the Animas River, Colorado, during snowmelt runoff (Church and others, 1997).

Aluminum, Copper, Manganese, and Zinc

The most striking difference between the profile of Ca load and the profiles of metal loads is the relative importance of the different sources. Sources of Ca load occur all along the study reach, but a large part of the metal loads comes from the Glengary adit and other mine-related sources in the first 700 m of the study reach (figs. 15, 16, 17, and 18). About 60 percent of the Al, Cu, Mn, and Zn loads can be accounted for by the concentrations in the samples of the visible inflows, and almost all of these loads entered Fisher Creek in the upper 700 m. This means the cumulative inflow load is much closer to the cumulative total load for these metals than for SO_4. The remaining 40 percent was from diffuse subsurface inflows. Considering this diffuse source, the reduction of metal loads in Fisher Creek might be limited unless there were a way to reduce loads from the diffuse sources as well as reducing loads from the Glengary adit and nearby mining wastes. For example, the load of Cu from the Glengary adit was 28 mg/s, which was 32 percent of the total load at the end of the study reach (fig. 15). A decrease of 32 percent of the load may not reduce Cu to concentrations that would be low enough for a healthy fish population. Also, eliminating inflow of the Glengary adit would increase the pH of Fisher Creek, and reduce the load of Fe, changing the dynamics of Cu sorption to Fe colloids. With these chemical complexities, the exact amount of reduction in Cu for eliminating a particular source needs to be estimated by a reactive solute-transport simulation; it is not a simple mass-balance question.

Loads for filtered Al, Cu, Mn, and Zn showed the same general pattern. The major loads from the Glengary adit and nearby mining wastes initially dominate the load profiles. Transport of that load was conservative for each metal to about 800 m. From 802 m to 1,582 m, the sampled instream load and the cumulative total loads diverged because of net losses in some stream segments as a result of chemical reactions. These decreases in load occurred downstream from neutral inflows that raised the instream pH. The decreases could have resulted from sorption of the metals to the Fe colloids or from coprecipitation with the Fe colloids. Amacher and others (1994) have shown a marked increase in the Cu concentration in the streambed Fe precipitates in this same area of Fisher Creek. None of the total-recoverable metal concentrations increased in this reach (table 6), indicating that there must have been sorption directly to bed material. After the instream metal loads decreased, each metal load subsequently increased between 1,582 m and 1,750 m. This area had no visible inflows; the increased load must represent metal-rich, subsurface inflow. The source of this metal-rich inflow was not apparent and should be investigated further.

The loading of Al was different from the other metals downstream from the inflow at 2,116 m (fig. 16a). With the increase in pH, Al precipitated, as indicated by the sharp decline in load. There was visible evidence of precipitation on the streambed cobbles along the right bank downstream from the inflow. The load of Cu also decreased in that reach, most likely as a result of sorption of Cu onto the Fe and Al precipitates rather than by precipitation of a solid phase. If Cu and other metals are stored on the streambed with Fe colloids, they could be flushed by the next snowmelt runoff.

Mass-load profiles of Mn (fig. 17) and Zn (fig. 18) were similar. For both, the Glengary adit was the principal source of the metal load. The largest losses occurred in the area from 1,402 m to 1,462 m and from 2,115 m to 2,235 m, both in response to inflows that had high pH. Between 1,750 m and 1,936 m the load of Zn increased due to subsurface inflows, but the Mn load did not increase. This could indicate a mineralogical difference between the source of metals in that area and the source of the Glengary adit.

Despite the differences in details among the mass-load profiles, the metal loads collectively indicate five areas where most of the metal loads entered the stream. The net gain or loss of metals in each stream segment is summarized in table 7. For each metal, the five largest increases are shaded to point out the principal areas of loading. The first area was between 257 m and 330 m, including the Glengary adit and the FCT-11 tributary. The second area was between 618 m and 725 m, where streams that drain waste-rock piles enter Fisher Creek. The third important area was between

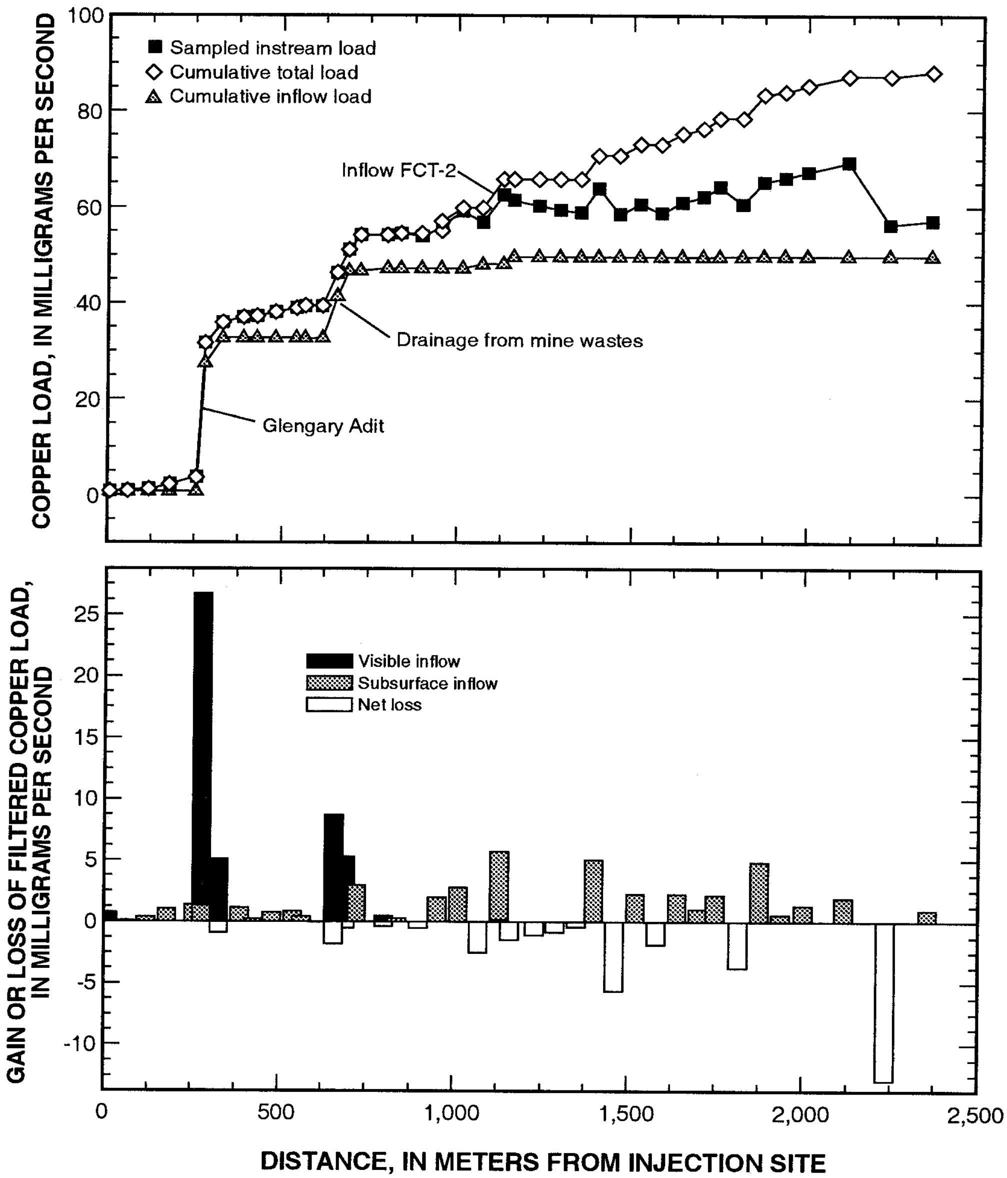

Figure 15. (a) Sampled instream load, cumulative total load, and cumulative inflow load of filtered copper, and (b) net gain or loss of filtered copper load, Fisher Creek, Montana, August 19, 1997.

1,072 m and 1,132 m, which receives the discharge from the largest visible inflow, FCT-2. A fourth area with substantial inflow was between 1,582 m and 1,750 m, where increased load was mostly from subsurface inflow and not visible inflows. Finally, the area from 1,876 m to 1,936 m had a considerable increase of load for Ca, Al, and Cu. This area likely drains carbonate outcrops on the right side of the canyon. The sources of Al and Cu are not clear, however, because drainage from the Gold Dust Mine does not appear to enter the inflow in this area.

SUMMARY

Acid mine drainage from past mining affects the water quality of Fisher Creek, Montana. To effectively plan for remediation requires detailed knowledge of the sources of the mine drainage, how the drainage from the sources enters the stream, and what natural attenuation may remove the metals once they are in the stream. The U.S. Geological Survey, in cooperation with the U.S. Environmental Protection Agency, conducted a tracer injection and synoptic sampling study to provide the information.

A chloride tracer injection allowed the calculation of discharge for synoptic samples along a 2,355-m reach of Fisher Creek. The study reach began upstream from the Glengary adit and ended in a downstream wetland, just upstream from site FC-5. The load profiles were calculated using discharge, calculated from the dilution of the tracer, and concentration data from detailed synoptic sampling. Loads of aluminum, copper, iron, manganese, and zinc greatly increased from the inflow of the Glengary adit. Downstream from the adit, metal transport was without substantial chemical reaction until the inflow of a tributary with higher pH (FCT-2), which caused instream pH to rise. Chemical reaction also decreased the loads of copper and aluminum in the wetland area, near the end of the study reach. At the higher pH, aluminum changed from the filtered phase to colloidal solids and started settling from the stream. Chemical reactions substantially affected the load profile of iron along the entire study reach. The copper and zinc load profiles indicated the significance of ground-water inflows near the bottom of the study reach.

Calculating the cumulative total load and the cumulative inflow load helps indicate the extent of metal removal and the likely sources of ground-water inflow. Removal of metal loads from the stream has two important consequences. First, the metals are stored in iron colloids each summer and then are flushed by snowmelt runoff, likely causing a large increase of colloidal metal load for many kilometers downstream. Second, accounting for the total load facilitates the illustration of individual sources of metal loads.

The similarity of load profiles for the metals points out the impacts of mine drainage on Fisher Creek. A large part of the metal loads comes from the inflow of the Glengary adit, but substantial loads of each metal also occurred at other locations. Some loads came from diffuse subsurface inflow. Eliminating only a single source, without considering all principal sources, may not reduce instream concentrations to levels that do not adversely affect aquatic life.

APPENDIX F

DISCUSSION AND SUMMARY FOR SODA BUTTE CREEK METALS SOURCES (EXCERPT FROM BOUGHTON, 2001)

Major Ions

The shape of the load profiles of the major ions indicates the locations of the major sources of those ions. Calcium detected in the stream originated mainly from weathering of limestone formations in the upper reaches of the basin. The largest contributions to the cumulative inflow load of dissolved calcium were by inflows between 505 m and 940 m (16 percent), between 1,785 m and 2,422 m (40 percent), and between 3,490 m and 3,720 m (16 percent) (fig. 13). The sampled instream load profile of dissolved calcium is similar to the cumulative instream load profile, indicating that little calcium was removed by chemical or physical processes in the stream. The cumulative inflow load was 51 percent of the cumulative instream load, indicating that the visible sampled inflows likely had lower calcium concentrations than the subsurface inflows.

The load profiles of dissolved silica are dominated by the contributions of Republic Creek (1,859 m). The cumulative inflow load of dissolved silica (fig. 14) was attributable mainly to two areas: inflows between 1,785 m and 2,422 m (53 percent) and between 8,247 m and 8,379 m (34 percent). The cumulative instream load was contributed mainly by inflows between 1,785 m and 2,422 m (67 percent) and between 8,247 m and 8,379 m (24 percent). The sampled instream load profile and cumulative instream load profile are similar, indicating that little silica was removed from the water column by chemical or physical processes.

The load profiles of dissolved sulfate reflect the effects of the ground-water seeps from the McLaren Mine tailings impoundment. Most of the cumulative inflow load of dissolved sulfate was contributed by the inflows between 505 m and 940 m (72 percent) (fig. 15). The cumulative instream load was contributed mainly by inflows between 505 m and 940 m (42 percent) and between 8,247 m and 8,379 m (13 percent). The sampled instream load and cumulative instream load profiles are similar. The difference between the smaller cumulative inflow load and the larger cumulative instream load indicates that the visi-

Metals

Metals bound to colloidal particles make up most of the difference between the total-recoverable and dissolved concentrations. Iron colloids are of particular interest because they have been shown to play a key role in metals transport in other Rocky Mountain streams receiving acid mine drainage (Kimball and others, 1995). Iron colloids can precipitate on the streambed and adversely affect the physical habitat of benthic aquatic organisms. Trace metals tend to sorb to iron colloids. A large percentage of the metal load in Soda Butte Creek was transported in the colloidal phase.

The load profiles of metals were more variable than those of the major ions because of physical and chemical processes in the mainstem. Iron is discussed first because of its importance in regulating the behavior of the other metals.

Accurate load calculations for iron were difficult to derive because of the highly reactive nature of this metal. Dissolved iron loads were small because most of the iron rapidly precipitated out of the neutral-pH waters of Soda Butte Creek as colloidal ferric oxide. Cumulative inflow load was attributable almost entirely to three areas: between 505 m and 760 m (48 percent), between 1,785m and 2,422m (18 percent), and between 8,247 m and 8,379 m (32 percent) (fig. 16). Most of the cumulative instream load (66 percent) was contributed by inflows between 1,785 m and 2,422 m. The large disparity between the total cumulative instream load (326 mg/s) and the sampled instream load (68.9 mg/s) at T4 is indicative of iron removal from the stream by chemical or physical processes.

The cumulative inflow load of total-recoverable iron (fig. 17) was attributable almost entirely to three areas: between 565 m and 760 m (26 percent), between 1,785m and 1,922m (38 percent), and between 8,247 m and 8,379 m (34 percent). Significant contributions to the cumulative instream load came from inflows between 1,785 m and 1,922 m (52 percent) and subsurface inflows between 8,247 m and 8,379 m (31 percent). The sampled instream load and cumulative instream load diverge downstream of 2,172 m, indicating removal of iron by chemical or physical processes.

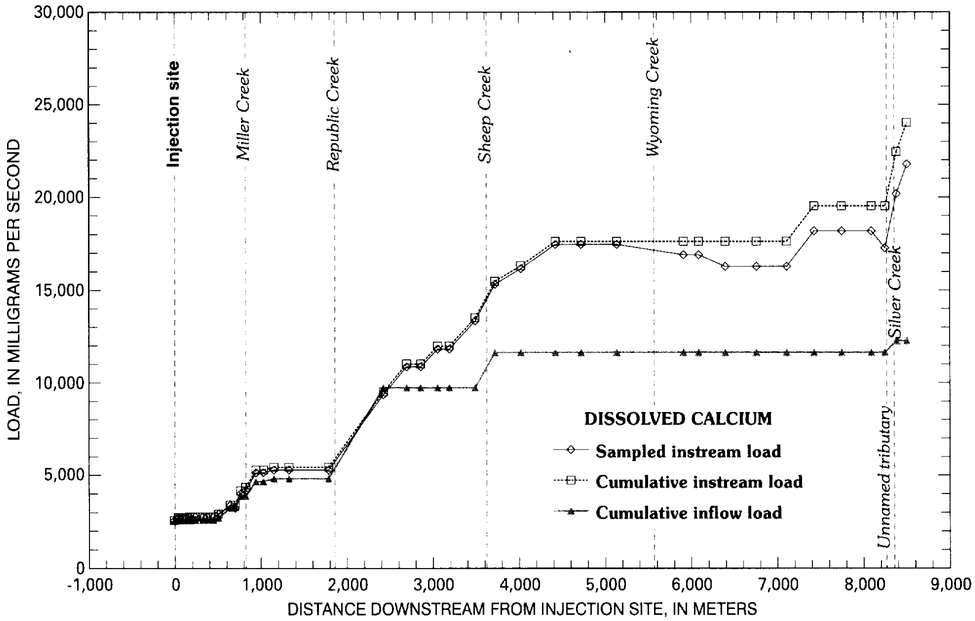

Figure 13. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved calcium, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

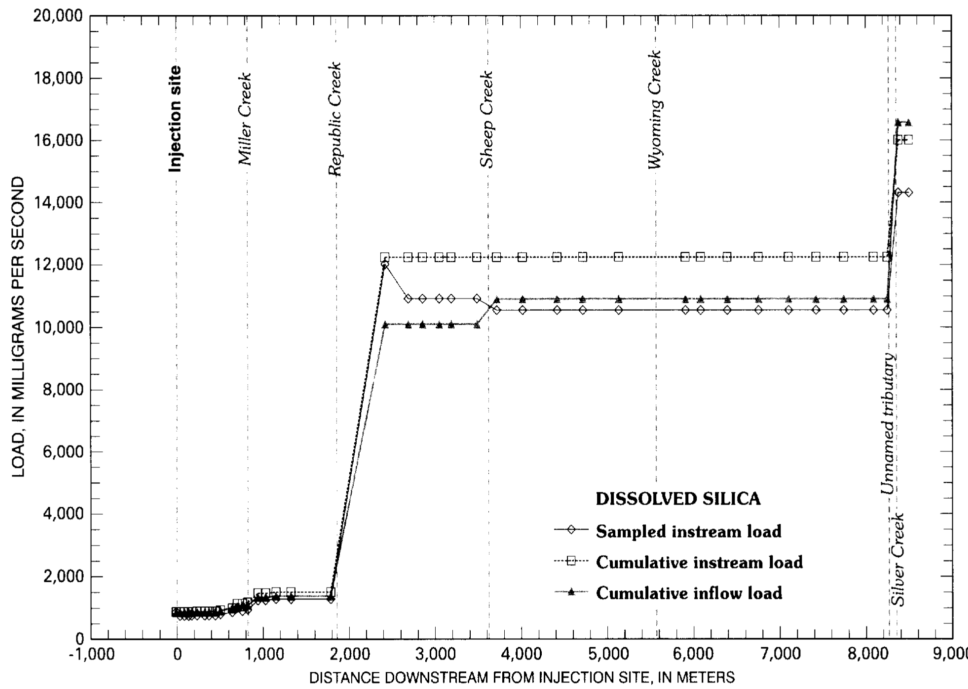

Figure 14. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved silica, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

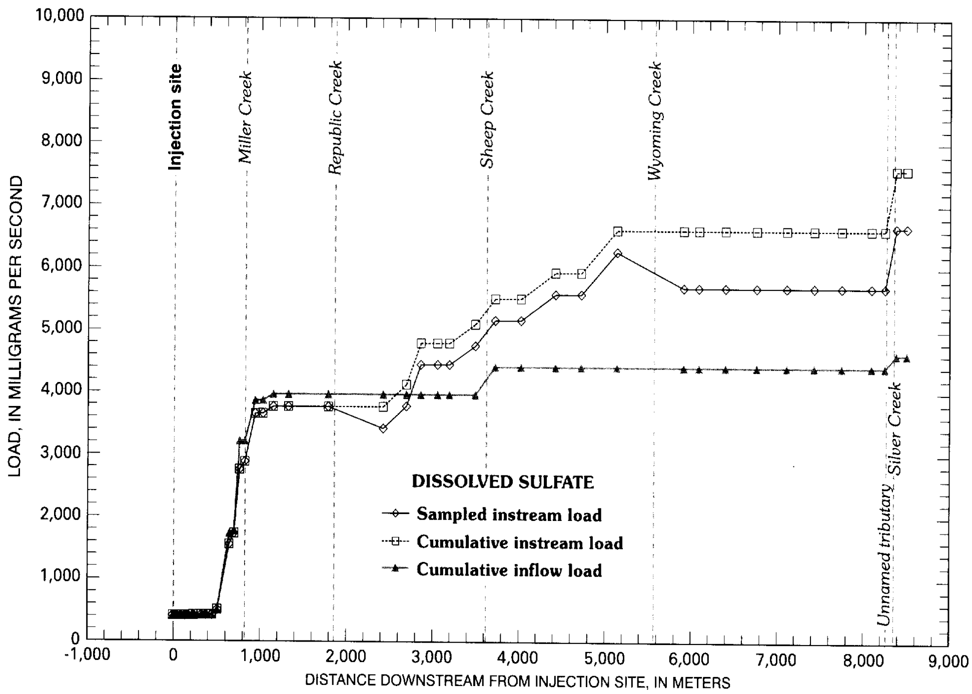

Figure 15. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved sulfate, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

Most of the cumulative inflow load of dissolved aluminum was contributed by the inflows between 1,785 m and 2,422 m (44 percent) and between 8,247 m and 8,379 m (50 percent) (fig. 18). The cumulative instream load was contributed mainly by inflows between 1,785m and 2,422 m (53 percent) and between 8,090 m and 8,379 m (23 percent). The cumulative instream load profile and sampled instream load profile diverge downstream of 2,422 m, indicating removal of aluminum by chemical or physical processes in that segment of the creek.

The total-recoverable aluminum load profiles (fig. 19) were very similar to those of total-recoverable iron (fig.17). The cumulative inflow load consisted mainly of the contributions from inflows between 1,785m and 1,922m (47 percent), and between 8,247 m and 8,379 m (45 percent). Significant contributions to the cumulative instream load came from inflows between 1,785 m and 2,172 m (52 percent), and between 8,247 m and 8,379 m (35 percent). The sampled instream load profile and cumulative instream load profile diverge downstream of 2,172 m, indicating removal of aluminum by chemical or physical processes in that segment of the creek.

Manganese concentrations were relatively low. Instream load profiles of elements detected at low concentrations tend to follow the shape of the discharge profile. The cumulative inflow load of dissolved manganese (fig. 20) consisted mainly of the contributions from the inflows between 505 m and 760 m (82 percent). The cumulative instream load was contributed mainly by inflows between 1,785 m and 2,422 m (52 percent), and between 8,247 m and 8,379 m (26 percent). The sampled instream load profile and cumulative instream load profile are identical, indicating no loss of dissolved manganese from the water column.

The cumulative inflow load of total-recoverable manganese consisted mainly of the contributions from inflows between 565 m and 760 m (80 percent) and between 1,785 m and 1,922 m (9 percent) (fig. 21). The

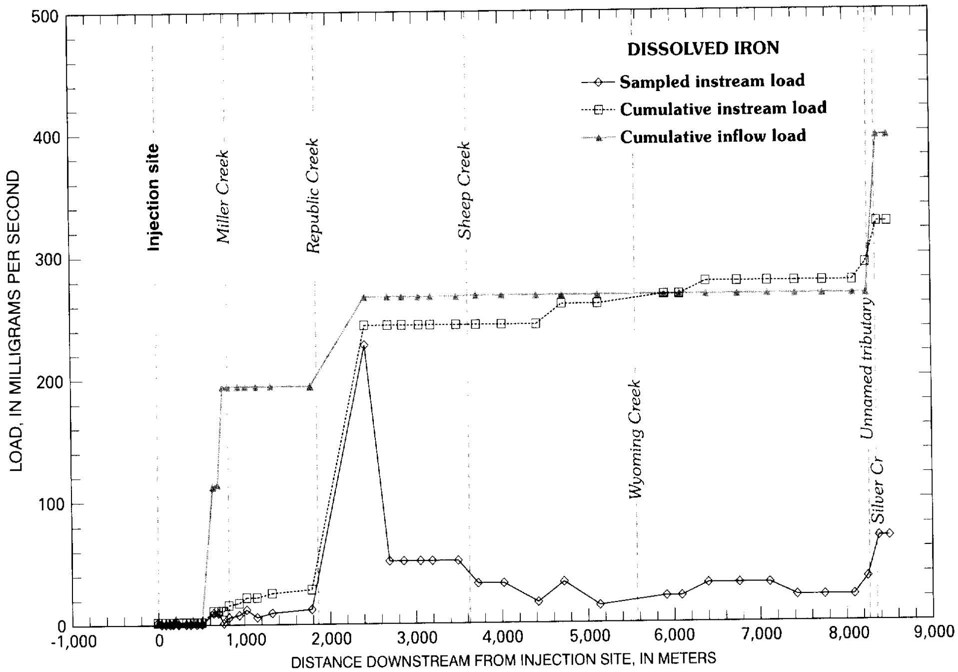

Figure 16. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved iron, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

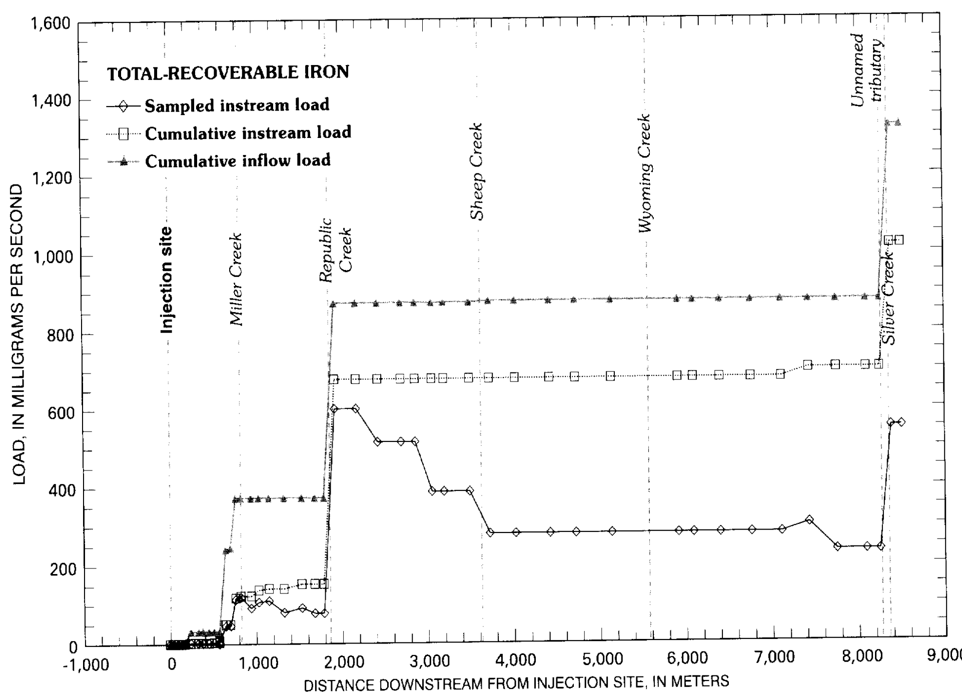

Figure 17. Sampled instream load, cumulative instream load, and cumulative inflow load of total-recoverable iron, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

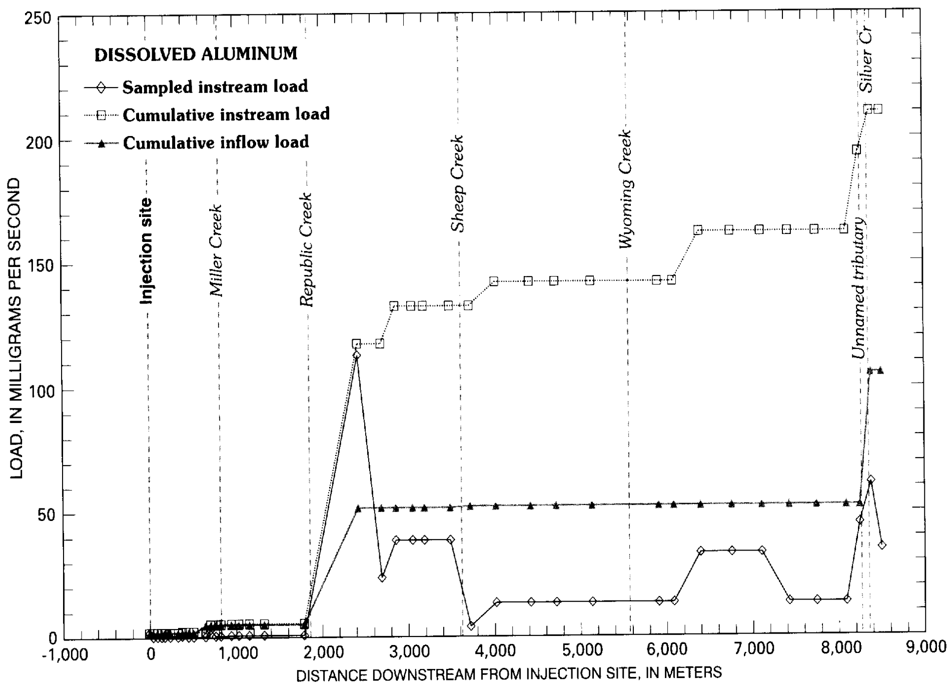

Figure 18. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved aluminum, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

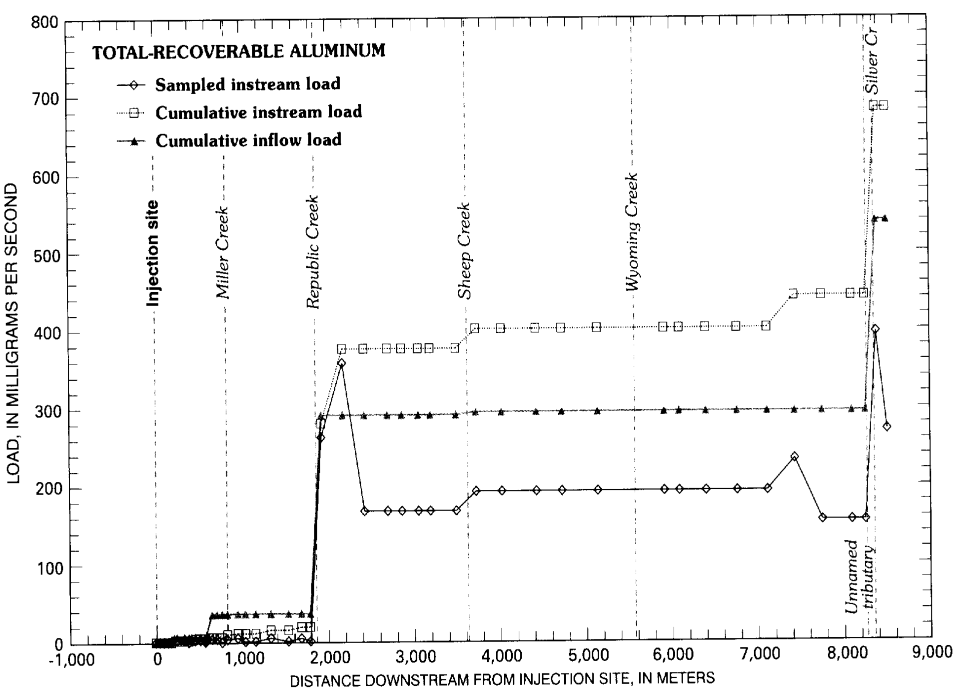

Figure 19. Sampled instream load, cumulative instream load, and cumulative inflow load of total-recoverable aluminum, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

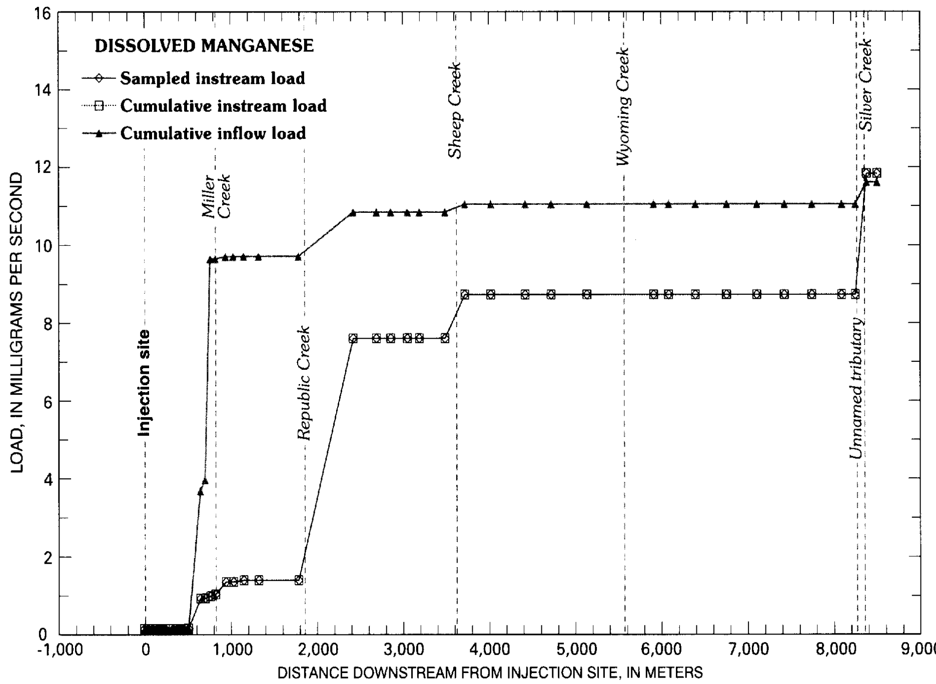

Figure 20. Sampled instream load, cumulative instream load, and cumulative inflow load of dissolved manganese, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

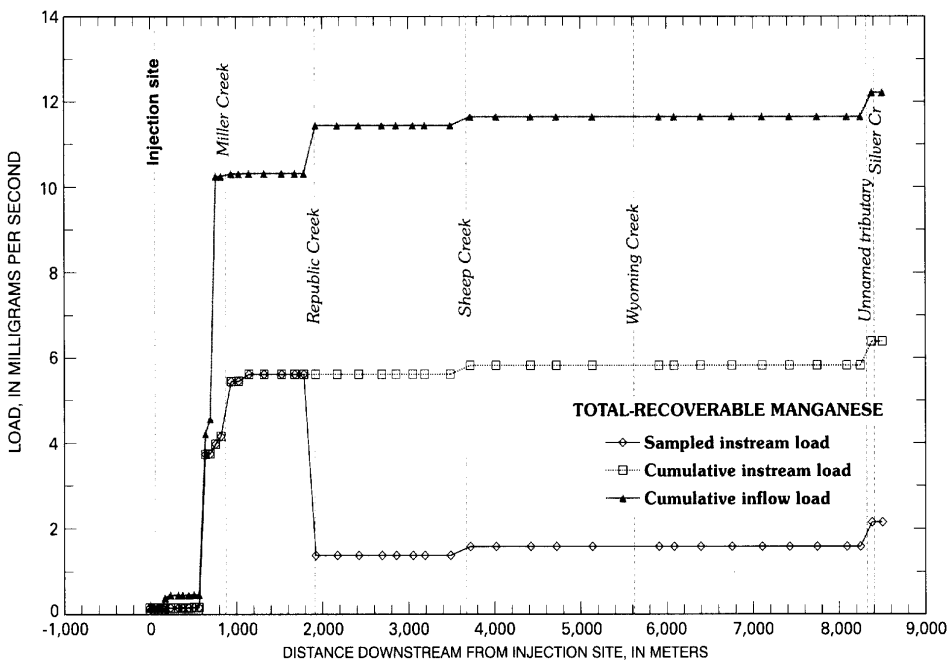

Figure 21. Sampled instream load, cumulative instream load, and cumulative inflow load of total-recoverable manganese, Soda Butte Creek, Montana and Wyoming, August 20, 1999.

cumulative instream load was contributed mainly by inflows between 565 m and 940 m (83 percent). The sampled instream load profile and cumulative instream load profile are very similar except for the stream segment from 1,785 m to 1,922 m. Along this reach, the sampled instream load dropped from 5.6 mg/s to 1.4 mg/s because of chemical or physical processes occurring in the stream.

Loads were not calculated for cadmium, copper, lead, and zinc even though minimum reporting levels for these metals approached or exceeded water-quality standards for the protection of aquatic life. The highest total-recoverable concentrations of cadmium (0.063 mg/L), copper (6.08 mg/L), lead (0.603 mg/L) and zinc (0.772 mg/L) were detected in the synoptic sample collected from site 569 m (a seep from the McLaren Mine tailings impoundment) (append. C). However, cadmium, copper, and lead were not detected in any of the mainstem synoptic samples, while the highest total-recoverable concentration of zinc in the mainstem of Soda Butte Creek was 0.044 mg/L at site 2,172 m. The lack of detection of these metals in the downstream mainstem synoptic samples, probably because of sorption (coprecipitation and adsorption) to metal colloids in the stream, prevented meaningful load calculations of these constituents.

These results agree with those of previous studies conducted in the area. Researchers analyzing water-column samples have detected very low concentrations of these elements (Miller and others, 1997). Other researchers analyzing the aquatic biota have attributed a decline in stream health along this segment of the creek to elevated trace-element concentrations, particularly copper (Forstner and Wittman, 1983; Nimmo and Willox, 1996).

Iron-rich colloids that settle to the streambed or are trapped by algae on streambed cobbles are flushed by snowmelt runoff the following year (Kimball and others, 1999). The water sample collected at the USGS gaging station at the YNP boundary during peak snowmelt runoff contained the highest metal loads of any sample collected during the 1999 water year. The total-recoverable iron concentration in the June 22, 1999 sample was 6.26 mg/L (append. D).

Metal Sources

The loading of metals at different points in the stream was compared to isolate areas of surface or ground-water inflow that may be contributing metals to the stream or diluting them. The magnitude of different sources relative to the whole system also was compared. The highest inflow metal concentrations do not always indicate the most significant sources of metal loading.

Examined collectively, the metal-load profiles indicate three areas contributing most of the metals to Soda Butte Creek. The three major areas of concern are the inflows from the McLaren Mine tailings impoundment (between 505 m and 760 m), Republic Creek (1,859 m), and Unnamed Tributary (8,267 m). The McLaren mill site did not contribute to metal loading in Soda Butte Creek during the tracer-injection and synoptic-sampling study because the site was dry. However, significant rill erosion was evident at the mill site immediately upgradient of Soda Butte Creek. During the spring snowmelt season, as well as during significant summer rainstorms, the McLaren mill site probably contributes to the metal loading of Soda Butte Creek.

Results indicate that treatment or removal of the McLaren Mine tailings impoundment would greatly reduce metal loading of Soda Butte Creek upstream of YNP. However, removing only that single source may not reduce metal loads to acceptable levels. The sources of metal loading in Republic Creek and Unnamed Tributary merit further investigation.

SUMMARY

Acid drainage from historic mining activities has affected the water quality and aquatic biota of Soda Butte Creek upstream of Yellowstone National Park. A retrospective analysis of previous research on metal loading in Soda Butte Creek was completed to provide summaries of studies pertinent to metal loading in Soda Butte Creek and the effects of the loading on the water quality and aquatic biota. None of the studies conducted on Soda Butte Creek have included an examination of the effects of metal loading on the entire basin.

The research was divided into studies of surface-water quality, fluvial geomorphology, and aquatic biota. In general, the more recent studies indicate that the health of the aquatic ecosystem continues to be negatively impacted by historic mining activities. Flooding could expose buried tailings sediments, wash fresh tailings sediments into the stream, or carry metal-contaminated aquatic biota into Yellowstone National Park. Such an event would likely cause a significant increase in metal loading in Soda Butte Creek.

A critical gap in the existing data was identification and quantification of the sources of metal loading to Soda Butte Creek. Although the McLaren Mine tailings impoundment and mill site has long been identified as a source of metals, its contribution relative to the total metal load entering Yellowstone National Park was unknown. A tracer-injection and synoptic-sampling study was designed to determine metal loads in Soda Butte Creek upstream of Yellowstone National Park.

The tracer-injection and synoptic-sampling study was conducted on an 8,511-meter reach of Soda Butte Creek from upstream of the McLaren Mine tailings impoundment and mill site downstream to the Yellowstone National Park boundary in August 1999. Synoptic-sampling sites were selected to divide the creek into discrete segments. A lithium bromide tracer was added to the stream. Stream discharge values, combined with constituent concentrations obtained by synoptic sampling, were used to quantify constituent loading in each segment of Soda Butte Creek.

Much of the metal load was transported in the colloidal phase. Of particular concern are the colloidal iron hydroxides, as they accumulate on the streambed. This accumulation adversely affects the aquatic biota by altering the physical habitat of aquatic organisms. In addition, metals can sorb to the colloids and create a chronic source of toxicity (Kimball and others, 1999).

Loads were calculated for dissolved calcium, silica, and sulfate, as well as for dissolved and total-recoverable iron, aluminum, and manganese. Loads were not calculated for cadmium, copper, lead, and zinc because these elements were infrequently detected in the mainstem synoptic samples. All of these elements were detected at high concentrations in the seeps from the McLaren Mine tailings impoundment. The lack of detection of these elements in the downstream mainstem synoptic samples is probably because of sorption (coprecipitation and adsorption) to metal colloids in the stream. These results agree with those of previous studies conducted in the area. Researchers analyzing water-column samples have detected very low concentrations of these elements (Miller and others, 1997). Other researchers analyzing the aquatic biota of Soda Butte Creek have attributed a decline in stream health along this segment of the creek to elevated trace-element concentrations, particularly copper (Forstner and Wittman, 1983; Nimmo and Willox, 1996).

Most of the metal load that entered Soda Butte Creek was contributed by three areas. The three major areas of concern are the inflows that drain the McLaren Mine tailings impoundment (between 505 m and 760 m downstream from the tracer-injection site), Republic Creek (1,859 m), and Unnamed Tributary (8,267 m). The McLaren mill site did not contribute to metal loading in Soda Butte Creek during the tracer-injection and synoptic-sampling study because the site was dry. However, significant rill erosion was evident at the mill site immediately upgradient of Soda Butte Creek. During the spring snowmelt season, as well as during significant summer rainstorms, the McLaren mill site probably contributes to the metal loading of Soda Butte Creek.

Results indicate that treatment or removal of the McLaren Mine tailings impoundment would greatly reduce metal loading of Soda Butte Creek upstream of Yellowstone National Park. However, removing only that single source may not reduce metal loads to acceptable levels. The sources of metal loading in Republic Creek and Unnamed Tributary merit further investigation.

APPENDIX G
METALS SOURCE ANALYSES FOR SODA BUTTE CREEK

METALS LOADING SOURCE ANALYSES FOR SODA BUTTE CREEK

These different loading source analyses are based on several data sources and are meant to help determine significant source areas for setting load allocations, assist with restoration planning, and identify data gaps. Many of the loading comparisons along different stream segments are conservative, and it is recognized that a portion of a load delivered to Soda Butte Creek from Miller Creek on any given day, especially during low flows, may end up deposited to the streambed prior to reaching downstream locations such as Yellowstone National Park.

Soda Butte Creek Metals Sources, Low Flow Conditions

Copper (Low Flow Conditions)

At low flow conditions, the main copper source is the McLaren Tailings Area as identified by inflow samples all along Soda Butte Creek (Boughton, 2001). The copper from the McLaren Tailings enters Soda Butte Creek via seeps and other ground water flows discharging to the stream. Historic ground water concentrations of copper in the McLaren Tailings average 9300 ug/l (Pioneer, 2001a). Inflow copper concentrations from several seeps from the tailings and other mine disturbances around the tailings during August 1999 were greater than 200 ug/l and as high as 6080 ug/l (Boughton, 2001). Given these concentrations, it is estimated that the copper load is at least 0.05 lb/day.

It is likely that most of the copper entering Soda Butte Creek from the McLaren Tailings co-precipitates with and adsorbs to metal colloids primarily associated with iron precipitates (see discussion on high iron loads from the McLaren Tailings below). This copper then leads to elevated levels in stream sediments and contributes to impairment concerns associated with aquatic life.

Soda Butte Creek upstream of the McLaren Tailings provides minor, insignificant loads of copper. Miller Creek is possibly the only other significant low flow source of copper to Soda Butte Creek, generally at levels that alone would not cause Soda Butte Creek copper values to be greater than the water quality standard, but high enough to cause elevated levels based on concentration and flows from Miller Creek (Maxim, 2001a). Even so, Miller Creek low flow copper loads are generally less than 0.02 lbs/day based on estimated seep flows and estimated average concentrations.

The synoptic study results show that copper levels all along Soda Butte Creek remain below 12 ug/l, leaving open the possibility that some sections of the stream were above the approximate 7 ug/l aquatic life support standard, but always below 12 ug/l. Most other data sources indicate that low flow copper levels tend to remain below the standard with an occasional value slightly above the standard (Appendix B). Data from Nimmo et al. suggests the possibility of significant copper loading from downstream sources since dissolved copper concentrations remained fairly constant with increasing flow during one of three years of low flow sampling.

The *Final Site Evaluation Report for the Republic Mine and Mill Site* (Pioneer, 2001b) and the *Final Reclamation Investigation for the Great Republic Smelter Site* (Tetra Tech EM Inc. 1999) both indicate low copper levels in water and sediment samples in the Woody/Republic Creek drainage during low flow conditions. However, some of the specific mine waste samples (slags, etc.) in this drainage are elevated in copper.

Iron (Low Flow Conditions)

Figure 17 in Appendix F shows three primary sources of total recoverable iron loads to Soda Butte Creek during low flow conditions. These include the McLaren Tailings Area (in the vicinity of Miller Creek on Figure 17), the Woody/Republic Creek drainage (referred to as Republic Creek in the report), and the Unnamed tributary just upstream of SBC4. Although total loading from the McLaren Tailings Area is lower than the other two sources, the impact from the tailings is most pronounced because of the relatively low flow in this section of the stream. Iron concentrations at or near SBC2 from this study and several other sources (Maxim 2001a, Pioneer 2001a) are routinely above 1000 ug/l and can be over 3000 ug/l, and staining associated with iron precipitates are evident in this area. Corresponding iron concentrations and loads in Miller Creek and Soda Butte Creek upstream of the tailings are consistently low.

The iron from the McLaren Tailings enters Soda Butte Creek via seeps and other ground water flows discharging to the stream. Historic ground water concentrations of iron in the McLaren Tailings average 2,300,000 ug/l (Pioneer, 2001a). Inflow concentrations from several seeps from the tailings and other mine disturbances around the tailings during August 1999 were typically greater than 24,000 ug/l and as high as 418,000 ug/l (Boughton, 2001).

Based on the synoptic study, iron concentrations further downstream of the immediate tailings impact area generally remain elevated above the 300 ug/l domestic use/drinking water support standard. This is primarily due to increased loads from the Woody/Republic Creek drainage (iron concentration at 885 ug/l) and from Unnamed Creek (iron concentration at 1580 ug/l). Iron concentrations in Wyoming Creek (1440 ug/l) and a few other small tributaries (915 ug/l to 1860 ug/l) near Unnamed Creek are also very high, but loading to Soda Butte Creek is low because of low flows associated with these tributaries.

Other data sources (USGS, 2001 & Maxim 2001a) show that iron is occasionally above the 1000 ug/l aquatic life support level at or near sampling locations SBSW-102 and SBC-4.

The *Final Site Evaluation Report for the Republic Mine and Mill Site* (Pioneer, 2001b) reports iron levels upstream and downstream of mine disturbances in Republic Creek, which flows into Woody Creek, in the range of 300 to 350 ug/l during a low flow period. This indicates that a portion of the load in this area may be associated with natural conditions. In general, there appears to be a lack of iron data for the Woody, Republic, Wyoming, and Unnamed Creek drainage areas. An assessment of potential sources of elevated metals may also be lacking for a few of these streams.

Sample location SBSW-102 is conveniently located on Soda Butte Creek below Woody/Republic Creek. Sample results (Maxim 2001a) from this location during low flow conditions, particularly during early spring, indicate significant sources of iron between Woody Creek and SBC-4, consistent with the synoptic sample results.

Manganese (Low Flow Conditions)
At low flow conditions, manganese is only a concern in Soda Butte Creek just downstream from the McLaren Tailings. This is supported by data from several sources (Pioneer 2001a, Maxim 2001a, others). Appendix F; Figure 21 shows that the manganese load is primarily from the McLaren Tailings. This is supported by consistently low manganese concentrations at SBC1 and SW5 at low flows (Maxim, 2001a), and in the area of SBC4 (USGS, 2001 and Maxim, 2001a), all under low flow conditions.

The manganese from the McLaren Tailings enters Soda Butte Creek via seeps and other ground water flows discharging to the stream. Historic ground water concentrations of manganese in the McLaren Tailings average 2,000 ug/l (Pioneer, 2001a). Inflow concentrations from several seeps from the tailings and other mine disturbances around the tailings during August 1999 were typically greater than 1000 ug/l and as high as 7740 ug/l (Boughton, 2001).

Lead (Low Flow Conditions)
Lead has generally not been considered a low flow concern, although the McLaren Tailings contribute to elevated levels in the stream and possibly in stream sediments. Synoptic sample results show one seep location from the McLaren Tailings with a concentration of 603 ug/l (Boughton, 2001). Relatively high detection levels (130 ug/l) during this synoptic study make it difficult to identify other potential low flow sources of concern or to identify problem areas in Soda Butte Creek. Available data from established monitoring locations (Maxim, 2001a), using much lower detection limits, do not show any values greater than standards at low flows.

Aluminum (Low Flow Conditions)
Dissolved aluminum under low flow conditions appears to only be a concern in Soda Butte Creek just below the confluence with the Woody/Republic Creek drainage, as shown by Figure 18 in Appendix F. The synoptic report (Boughton, 2001) describes the source of this aluminum as follows:
"Aluminum and silica detected in the water result from both mining activities and natural weathering of feldspars and other aluminosilicate minerals in the watershed."

Soda Butte Creek Metals Sources, High Flow Conditions

Copper (High Flow Conditions)
Upstream of the McLaren Tailings, copper levels in Soda Butte Creek are low with a few values above detection up to the highest value of 6 ug/l (load = 0.9 lbs/day) measured at the highest flow (Maxim, 2001a). Based on a larger set of data, copper levels in Miller Creek during high flows at SW5 ranged from 9 ug/l to 200 ug/l, representing a copper load to Soda Butte Creek as high as 73 lbs/day. On the same high flow day that the above referenced upstream Soda Butte Creek load was 0.9 lbs/day, the Miller Creek copper load was 6 lbs/day. This indicates significantly higher copper loads from Miller Creek in comparison to the upper segment of Soda Butte Creek.

At or near sample location SBC-4, copper concentrations can be as high as 22.4 ug/l during the highest flows, with loads up to 70 lbs/day. High flow copper loads from Miller Creek alone could account for most of this load based on the limited amount of data. Some portion of the elevated copper load likely comes from the McLaren Tailings and copper precipitated to stream sediments.

Transport of copper from mine waste materials in the Woody/Republic Creek and other drainage areas represents another potential source of copper. As discussed under low flow copper sources, at least some of the mine waste materials in this drainage are high in copper. Additional loading may also come from floodplain deposits associated with the 1950 tailings dam failure and subsequent large flood events, or from other tributaries.

Iron (High Flow Conditions)
Upstream of the McLaren Tailings, iron levels in Soda Butte Creek (SBC1 data via Maxim, 2001(a)) ranged from 110 ug/l (load = 7.6 lbs/day) to 490 ug/l (load = 76 lbs/day) during the two highest flow sample events. This indicates probable elevated iron loads from this source area during high flows. It appears as though SBC1 is situated such that some of the loading may be contaminated soils eroded from the adjacent McLaren Mill site on the north side of the stream (Boughton, 2001). Based on a larger set of data, iron levels in Miller Creek during high flows at SW5 ranged from 70 ug/l to 3,220 ug/l, with most values being greater than 300 ug/l.

On the same day that the Soda Butte Creek iron load was 76 lbs/day at SBC1, the corresponding iron load from Miller Creek was 110 lbs/day based on a concentration of 540 ug/l. This indicates potentially similar loads from both source areas. At even higher flows, Miller Creek iron concentrations were greater than 3000 ug/l in three out of four samples, indicating even much higher loads to Soda Butte Creek up to and above 1500 lbs/day. Unfortunately there is no corresponding high flow data for the upstream segment of Soda Butte Creek.

There is a general lack of high flow data just below the McLaren Tailings. During one sample event (Maxim 2001a; 7/7/00 sample date), the iron load at SBC2 was significantly higher (36 lbs/day) than the combined loads from Miller Creek and upper Soda Butte Creeks (5 lbs/day). This particular event was not representative of the near peak runoff events, but does indicate that the McLaren Tailings Area continues to have negative impacts on water quality with increasing flow. Recent 2001 data also support this conclusion (Maxim, 2001a).

At or near SBC4 just upstream of Yellowstone National Park (USGS 2001), iron concentrations range from 300 to 6,260 ug/l when flows are between 100 cfs and 632 cfs, with the two highest levels (5200 and 6260 ug/l) corresponding to the two highest flows. Iron loads range from 179 lbs/day to over 17,000 lbs/day. If it were assumed that natural background iron concentrations during high flows were as high as the 300 ug/l standard, then the natural background load could be as much as 6% of the total load during high flow events. Based on the Miller Creek and upper Soda Butte Creek data discussed above, these streams combined may typically contribute as much as 20% of the load. This leaves as much as 74% of the load unaccounted for during the high flow conditions.

Some portion of the elevated high flow load comes from the McLaren Tailings, including re-suspension of iron precipitants that settled to the streambed during low flows. Figure 17 in Appendix F indicates that the McLaren Tailings contribute about 350 g/sec (about 66 lbs/day) load during low flow to Soda Butte Creek. Based on the difference between the sampled in-stream load and inflow load, it appears as though as much as 80% of this total recoverable load (53 lbs/day) is deposited to the streambed. If this represented the average load deposited during the lowest flowing 300 to 330 days of the year, and this load was then re-suspended during the highest flowing 15 to 30 days, then there could be an additional load of about 530 to 1166 lbs/day during those 15 to 30 highest flow days. This would be added to the 66 lbs/day coming from the tailings already, which could be even higher under higher ground water flow conditions anticipated during runoff periods. This analysis indicates that the McLaren Tailings load still may only account for about 5 - 10% of the total load at SBC4 under the highest flow conditions, but it would be a much greater percent of the total load in the vicinity of SBC2 (20 - 40%).

The iron concentrations reported in the synoptic study (Boughton, 2001) for Woody/Republic Creek, Wyoming Creek, and Unnamed Creek indicate that these drainage areas produce the majority of the additional iron loading. Additional loading may also come from floodplain deposits associated with the 1950 tailings dam failure and subsequent large flood events, or from other tributaries.

Manganese (High Flow Conditions)

Upstream of the McLaren Tailings, manganese levels in Soda Butte Creek remain low at higher flows (Maxim, 2001a). Based on a larger set of data, manganese levels in Miller Creek at SW5 were 110 ug/l (load = 30 lbs/day) to 130 ug/l (load = 62 lbs/day) for the two highest flow events, with all other values well below levels of concern.

At most high flows at or near SBC-4 (USGS 2001), manganese levels range from 6 to 58 ug/l, but at the two highest flows manganese levels are 210 ug/l (load = 565 lbs/day) and 155 mg/l (load = 523 lbs/day). If it were assumed that natural background concentrations during high flows were as much as 25 ug/l, then the natural background load could be as much as 15% of the total load during high flows. Based on the Miller Creek and upper Soda Butte Creek data discussed above, these streams combined may typically contribute as much as 25% of the load, most of it coming from Miller Creek. This leaves as much as 60% of the load unaccounted for at this highest flow scenario.

Some portion of this elevated load likely comes from the McLaren Tailings. Based on Figure 21 in Appendix F, it appears as though as much as 50% of the approximate 2 lb/day manganese load may end up deposited to the streambed. Using the same analysis as was done for iron, daily high flow manganese loads from the tailings are estimated to be in the range of 2 to 5% (11 to 23 lbs/day) near SBC4, and 20 to 60% of the total load in the vicinity of SBC2.

Another probable source of manganese is from the Republic smelter, mine and mill sites in the Woody/Republic Creek drainage area. Mine waste and soil samples in mining areas have significantly elevated levels of manganese when compared to background in this area (Pioneer, 2001b and Tetra Tech, 1999). Additional loading may also come from floodplain deposits associated with the 1950 tailings dam failure and subsequent large flood events, or from other tributaries.

Lead (High Flow Conditions)
Upstream of the McLaren Tailings, lead levels in Soda Butte Creek remain low at higher flows (Maxim, 2001a). Based on a larger set of data, lead levels in Miller Creek at SW5 were from 3 ug/l (load = 0.8 lbs/day) to 22 ug/l (load = 11 lbs/day) for the two highest flow events.

At flows greater than 100 cfs at SBC-4, lead levels range from < 1 to 58 ug/l, and lead loads can be as high as 40 lbs/day. If Miller Creek accounts for as much as 11 lbs/day, then this could represent 28% of the total load under worst case conditions. This leaves as much as 72% or more of the load unaccounted for at the highest flow scenarios. Some portion of this elevated load comes from the McLaren Tailings. A probable source of some of the lead is from the Republic smelter, mine and mill sites in the Woody/Republic Creek drainage area. Mine waste and soil samples near mining areas in this drainage have significantly elevated levels of lead when compared to background levels in this area (Pioneer, 2001b and Tetra Tech, 1999). Additional loading may also come from floodplain deposits associated with the 1950 tailings dam failure and subsequent large flood events, or from other tributaries.

Aluminum (High Flow Conditions)
The data at SBC4 (USGS 2001a) consistently show low dissolved aluminum concentrations at low and high flows over the past few years. Data is currently lacking at SBSW102 and SBC2 to sufficiently determine whether or not there is a high flow dissolved aluminum problem upstream of SBC4. There are potentially high loads of dissolved aluminum associated with both Woody/Republic Creek and Miller Creek, where dissolved aluminum data are lacking under high flow conditions. Miller Creek data does show a high load of total recoverable aluminum, which can contribute to dissolved aluminum loads under the right geochemical conditions.

APPENDIX H

CLEANUP/RESTORATION AND FUNDING OPTIONS FOR MINE OPERATIONS OR OTHER SOURCES OF METALS CONTAMINATION

CLEANUP/RESTORATION AND FUNDING OPTIONS FOR MINE OPERATIONS OR OTHER SOURCES OF METALS CONTAMINATION

There are several approaches for cleanup of mining operations or other sources of metals contamination in the State of Montana. Most of these are discussed below, with focus on abandoned or closed mining operations.

1.0 The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA is a Federal law that addresses cleanup on sites, such as historic mining areas, where there has been a hazardous substance release or threat of release. Sites are prioritized on the National Priority List (NPL) using a hazard ranking system with significant focus on human health. Petroleum related products and associated raw materials are not covered under CERCLA. Other Federal regulations such as Resource Conservation and Recovery Act and associated Leaking Underground Storage Tank cleanup requirements tend to address petroleum.

Under CERCLA, the potentially responsible party or parties must pay for all remediation efforts based upon the application of a strict, joint and several liability approach whereby any existing or historical land owner can be held liable for restoration costs. Where viable landowners are not available to fund cleanup, funding can be provided under Superfund authority. Federal agencies can be delegated Superfund authority, but cannot access funding from Superfund.

Cleanup actions under CERCLA must be based on professionally developed plans and can be categorized as either Removal or Remedial. Removal actions can be used to address the immediate need to stabilize or remove a threat where an emergency exists. Removal actions can also be non-time critical, which is the situation for the New World Mining District cleanup efforts under the direction of the United States Forest Service, as discussed in this document.

Once removal activities are completed, a site can then undergo Remedial Actions or may end up being scored low enough from a risk perspective that it no longer qualifies to be on the NPL for Remedial Action. Under these conditions the site is released back to the state for a "no further action" determination. At this point there may still be a need for additional cleanup since there may still be significant environmental threats or impacts, although the threats or impacts are not significant enough to justify Remedial Action under CERCLA. Any remaining threats or impacts would tend to be associated with wildlife, aquatic life, or aesthetic impacts to the environment or aesthetic impacts to drinking water supplies versus threats or impacts to human health. A site could, therefore, still be a concern from a water quality restoration perspective, even after CERCLA removal activities have been completed. This may end up being the situation for the McLaren Tailings.

Remedial actions may or may not be associated with or subsequent to removal activities. A remedial action involves cleanup efforts whereby Applicable or Relevant and Appropriate Requirements and Standards (ARARS), which include state water quality standards, are satisfied. Once ARARS are satisfied, then a site can receive a "no further action" determination.

2.0 The Montana Comprehensive Cleanup and Restoration Act (CECRA)

The 1985 Montana Legislature passed the Environmental Quality Protection Fund Act. This Act created a legal mechanism for the Department to investigate and clean up, or require liable persons to investigate and clean up, hazardous or deleterious substance facilities in Montana. The 1985 Act also established the Environmental Quality Protection Fund (EQPF). The EQPF is a revolving fund in which all penalties and costs recovered pursuant to the EQPF Act are deposited. The EQPF can be used only to fund activities relating to the release of a hazardous or deleterious substance. Although the 1985 Act established the EQPF, it did not provide a funding mechanism for the Department to administer the Act. Therefore, no activities were conducted under this Act until 1987.

The 1987 Montana Legislature passed a bill creating a delayed funding mechanism that appropriated 4 percent of the Resource Indemnity Trust (RIT) interest money for Department activities at non-National Priority List facilities beginning in July 1989 (§ 15-38-202 MCA). In October 1987, the Department began addressing state Superfund facilities. Temporary grant funding was used between 1987 and 1989 to clean up two facilities and rank approximately 250 other facilities. Beginning in fiscal year 1995, the 4 percent allocation was changed to 6 percent to adjust for other legislative changes in RIT allocations. Effective July 1, 1999, the 6 percent allocation was increased to 9 percent.

The 1989 Montana Legislature significantly amended the Act, changing its name to the Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA) and providing the Department with similar authorities as provided under the federal Superfund Act (CERCLA). With the passage of CECRA, the state Superfund program became the CECRA Program. Major revisions to CECRA did not occur until the 1995 Legislature, when the Voluntary Cleanup and Redevelopment Act (VCRA), a mixed-funding pilot program, and a requirement to conduct a collaborative study on alternative liability schemes were added and provisions related to remedy selection were changed. Based on the results of the collaborative study, the 1997 Legislature adopted the Controlled Allocation of Liability Act, which provides a voluntary process for the apportionment of liability at CECRA facilities and establishes an orphan share fund. Minor revisions to CECRA were also made by the 1999 and 2001 Legislatures.

Currently, 208 facilities on the CECRA Priority List remain to be addressed; current actions are being conducted at 59 of those facilities. To date, 79 facilities are delisted because they are cleaned up or being addressed by another program. CECRA facilities are ranked maximum, high, medium, low and operation and maintenance priority based on the severity of contamination at the facility and the actual and potential impacts of contamination to public health, safety, and welfare and the environment. The Department maintains database narratives that explain contamination problems and status of work at each state Superfund facility. As of November 2001, final cleanup had been completed at 49 CECRA facilities, and interim cleanups had been completed at 78 facilities.

2.1 The Controlled Allocation of Liability Act (CALA)

The Montana Legislature added the Controlled Allocation of Liability Act (CALA; §§ 75-10-742 through 752, Montana Code Annotated (MCA)) to the Comprehensive Environmental Cleanup and Responsibility Act (CECRA; §§ 75-10-701 through 752, MCA), the state Superfund law, in 1997. The department administers CALA including the orphan share fund it establishes.

CALA is a voluntary process that allows Potentially Responsible Parties (PRP) to petition for an allocation of liability as an alternative to the strict, joint and several liability scheme included in CECRA. CALA provides a streamlined alternative to litigation that involves negotiations designed to allocate liability among persons involved at facilities requiring cleanup, including bankrupt or defunct persons. Cleanup of these facilities must occur concurrently with the CALA process and CALA provides the funding for the orphan share of the cleanup. Since CECRA cleanups typically involve historical contamination, liable persons often include entities that are bankrupt or defunct and not affiliated with any viable person by stock ownership. The share of cleanup costs for which these bankrupt or defunct persons are responsible is the orphan share. Department represents the interests of the orphan share throughout the CALA process.

The funding source known as the orphan share fund is a state special revenue fund created from a variety of sources. These include an allocation of 8.5 percent of the metal mines license tax, certain penalties and additional funds from the resource indemnity trust fund and 25 percent of the resource indemnity and groundwater assessment taxes (which will increase to 50 percent when the RIT reaches $100 million). The current balance of the Orphan Share Fund is around $4 million and revenues projected for the rest of this biennium are about $2 million.

In the absence of a demonstrated hardship, claims for orphan share reimbursement may not be submitted until the cleanup is complete. This ensures that facilities are fully remediated before reimbursement. The result is that a PRP could be expending costs it anticipates being reimbursed for some time before the PRP actually submits a claim.

CALA was designed to be a streamlined, voluntary allocation process. For facilities where a PRP does not initiate the CALA process, strict, joint and several liability remains. Any person who has been noticed as being potentially liable as well as any potentially liable person who has received approval of a voluntary cleanup plan can petition to initiate the CALA process. CALA includes fourteen factors to be considered in allocating liability. Based on these factors causation weighs heavily in allocation but is not the only factor considered.

2.2 The Voluntary Cleanup and Redevelopment Act (VCRA)

The 1995 Montana Legislature amended the Comprehensive Environmental Cleanup and Responsibility Act (CECRA), creating the Voluntary Cleanup and Redevelopment Act (VCRA) (Sections 75-10-730 through 738, MCA). VCRA formalizes the voluntary cleanup process in the state. It specifies application requirements, voluntary cleanup plan requirements, agency review criteria and time frames, and conditions for and contents of no further action letters.

The act was developed to permit and encourage voluntary cleanup of facilities where releases or threatened releases of hazardous or deleterious substances exist, by providing interested persons with a method of determining what the cleanup responsibilities will be for reuse or redevelopment of existing facilities. Any entity (such as facility owners, operators, or prospective purchasers) may submit an application for approval of a voluntary cleanup plan to the Department. Voluntary Cleanup Plans (VCPs) may be submitted for facilities whether or not they are on the CECRA Priority List. The plan must include (1) an environmental assessment of the facility; (2) a remediation proposal; and (3) the written consent of current owners of the facility or property to both the implementation of the voluntary cleanup plan and access to the facility by the applicant and its agents and Department. The applicant is also required to reimburse the Department for any costs that the state incurs during the review and oversight of a voluntary cleanup effort.

The act offers several incentives to parties voluntarily performing facility cleanup. Any entity can apply and liability protection is provided to entities that would otherwise not be responsible for site cleanup. Cleanup can occur on an entire facility or a portion of a facility. The Department cannot take enforcement action against any party conducting an approved voluntary cleanup. The Department review process is streamlined: the Department has 30 to 60 days to determine if a voluntary cleanup plan is complete, depending on how long the cleanup will take. When the Department determines an application is complete, it must decide within 60 days whether to approve or disapprove of the application; these 60 days also includes a 30-day public comment period. The Department's decision is based on the proposed uses of the facility identified by the applicant and the applicant conducts any necessary risk evaluation. Once a plan has been successfully implemented and Department costs have been paid, the applicant can petition the Department for closure. The Department must determine whether closure conditions are met within 60 days of this petition and, if so, the Department will issue a closure letter for the facility or the portion of the facility addressed by the voluntary cleanup.

The act is contained in §§ 75-10-730 through 738, MCA. Major sections include: § 75-10-732 - eligibility requirements; § 75-10-733 and § 75-10-734 - environmental property assessment and remediation proposal requirements; § 75-10-735 - public participation; § 75-10-736 - timeframes and procedures for Department approval/disapproval; and § 75-10-737 - closure process. Section 75-10-721, MCA of CECRA must also be met.

The Department does not currently have a memorandum of agreement (MOA) with the Environmental Protection Agency (EPA) for its Voluntary Cleanup Program. However, the Department and EPA are in the process of negotiating one. EPA has indicated that Montana's Voluntary Cleanup Program includes the necessary elements to establish the MOA. Currently, EPA is reviewing the latest draft of the MOA.

The Department has produced a VCRA Application Guide to assist applicants in preparing a new application; this guide is not a regulation and adherence to it is not mandatory.

As of November 2001, the Department has approved twenty voluntary clean plans for 19 facilities, including mining, manufactured gas, wood treating, dry cleaning, salvage, pesticide, fueling, refining, metal plating, defense, and automotive repair facilities. Applicants have expressed interest and/or submitted applications for voluntary cleanup at fifteen other facilities. The Department maintains a registry of VCRA facilities.

3.0 Abandoned Mine Lands Cleanup

The purpose of the Abandoned Mine Lands Reclamation (AML) Program is to protect human health and the environment from the effects of past mining and mineral processing activities. Funding for cleanup is via the Federal Abandoned Mine Fund, which is distributed to the State of Montana via a grant program. The Abandoned Mine Fund is generated by a per ton fee levied on coal producers and the annual grant it based on coal production. Expenditures under the abandoned mine program can only be made on "eligible" abandoned mine sites. For a site to be eligible, mining must have ceased prior to August 4, 1977 (private lands, other dates apply to federal lands). In addition, there must be no continuing reclamation responsibility under any state or federal law. No continuing reclamation responsibility can mean no mining bonds or permits have been issued for the site, however, it has also been interpreted to mean that there can be no viable responsible party under State or Federal laws such as CERCLA or CECRA. While lands eligible for the Abandoned Mine Funds include hard rock mines and gravel pits, abandoned coalmines have the highest priority for expenditures from the Fund. Cleanup of any eligible site is prioritized based primarily on human health, which can include health risks such as open shafts, versus risks only associated with hazardous substances, as is the case under CERCLA.

Montana's AML Program maintains an inventory of all potential cleanup sites, and also has a list of priority sites from which to work from. This includes sites such as the Republic Mine and Smelter Site discussed within this report. The Montana Department of Environmental Quality conducts cleanups under the Abandoned Mine Funds as public works contracts utilizing professional engineers for design purposes and private construction contractors to perform the actual work.

Mitigating impacts associated with discharging adits can be included within the cleanup, although ongoing water treatment is not pursued as a reclamation option to avoid long-term operational commitments, which are outside the scope of the program and funding source. Therefore, even after cleanup, an abandoned mine site could still represent a source of contaminant loading to a stream, especially if there is a discharging adit associated with the site. Where discharging adits are not of concern, cleanup may generally represent efforts to achieve all reasonable land, water, and soil conservation practices for that site.

A Guide to Abandoned Mine Reclamation (MDEQ, 1996) provides further description of the Abandoned Mine Lands Program and how cleanup activities are pursued.

4.0 Cleanup on Federal Agency Lands

A Federal land management agency may pursue cleanup actions outside of any requirements under CERCLA or CECRA where such activities are consistent with overall land management goals and funding availability. This is the anticipated solution for mines in the Cooke City TMDL Planning Area that are located on Forest Service property and meet certain criteria. This criteria would likely include the following: the site is part of the loading problem to Soda Butte Creek or other streams not addressed by New World Mining District Restoration and there does not appear to be a viable party or person other than the Forest Service.

5.0 Permitted or Bonded Sites

Newer mining sites that are or have been in recent operation are required to post bonds as part of their permit conditions. These bond and permit conditions help ensure cleanup to levels that will satisfy Montana Water Quality Standards during operation and after completion of a mining operation. Such sites also include larger placer mines greater than 5 acres in size. There are not any permitted or bonded sites in the Cooke City TMDL Planning Area.

6.0 Voluntary Cleanup Agreement

At least one location within Montana (the Upper Blackfoot Mining Complex) is being addressed via a voluntary cleanup approach based on an agreement between the responsible person and the State of Montana. Although similar in nature to the goals of CECRA, this cleanup effort is currently not considered a remedial action under CECRA. The responsible person is responsible for cleanup costs in this situation.

7.0 Landowner Voluntary Cleanup Outside of a State Directed or State Negotiated Effort

A landowner could pursue cleanup outside the context of CECRA or other state negotiated cleanup approaches. Under such conditions, liability would still exist since there is presumably a lack of professional oversight and assurance of meeting appropriate environmental and human health goals. Regulatory requirements such as where waste can be disposed, storm water runoff protection, and multiple other environmental conditions would still need to be followed to help ensure that the cleanup activity does not create new problems. This approach can be risky since the potential for additional future work would likely make it more cost effective to pursue cleanup under CECRA or some other state negotiated approach where PRP liability can be resolved.

8.0 State Emergency Actions

Where a major emergency exists, the State can undertake remedial actions and then pursue reimbursement from a responsible party. This situation does not exist in the Cooke City TMDL Planning Area.

FUNDING OPTIONS AND CONSIDERATIONS

Many of the above cleanup options to address mining related sites revolve around funding availability and therefore must be of adequate priority to tap into available funds. Funded actions in the Cooke City Planning Area appear to be limited to CERCLA actions as defined by the Consent Decree and also as defined by previous efforts that have focused on the McLaren Tailings; AML priority sites which include the Republic Mine and Smelter sites; and possibly some Forest Service actions to address individual mine locations outside the context of New World Mining District requirements. These funded activities will end up addressing the majority of the significant metals loading sources.

Additional assessment projects still need to be funded to better identify the relative load contributions during high and low flow conditions from many of the specific mining and other metals related sources outside the scope of the New World Mining District restoration efforts. Where specific sites are identified as significant sources of metals loading, then an approach needs to be identified to address the problem. In some situations, there may be PRPs that would be interested in pursuing cleanup under CECRA/CALA. Where a viable or voluntary party is not available, then funding options need to be identified and pursued to address cleanup efforts. One option involves funding via the yearly RIT/Resource Development Grant Program (RDGP), which can supply up to $300K to address environmental related issues. This money can be applied to sites that are AML eligible but of low enough priority where cleanup under AML is uncertain, and can also be used for further assessment/characterization work.

Another potential funding source is via the EPA Section 319 Nonpoint Source yearly grant program. This money is typically used to help identify, prioritize, and implement water quality protection projects with focus on TMDL development and implementation of nonpoint source projects. Individual contracts under the yearly grant typically range from $20K to $150K, with a 25 percent match requirement. RIT/RDGP and 319 projects typically need to be administered via a non-profit or local government such as a conservation district or a county.

There are likely several other grant programs and funding sources that could be utilized to help protect water quality and address environmental concerns, especially where such concerns are associated with the headwaters to Yellowstone National Park. State and Federal agencies are often able to provide some assessment-related support. Where sufficient funding can be obtained, then detailed assessment and cleanup such as might occur under VCRA, could be pursued.

APPENDIX I
DEQ RESPONSES TO PUBLIC COMMENTS

DEQ RESPONSES TO PUBLIC COMMENTS

<u>COMMENT</u>: The following two comments are closely related concerning the selection of aquatic life support targets.

- Refer to page 1-4, Table 1-2. Here and in other places "Cold Water Fish" is appropriately mentioned as a beneficial use not fully supported as a result of water quality impairment. We suggest adding where appropriate through the plan that, "full restoration of this use be evidenced by the presence of food organisms, spawning habitat and other requirements for sustainable populations of cold water fisheries". This would be one of the most comprehensive indicators of successful restoration.

- Refer to page 1-12, third paragraph. It states that, "Within Montana, the Soda Butte fishery is limited". We urge that a specific goal of this plan be that a viable, self-sustaining fishery be reestablished between the Miller Creek confluence and Yellowstone Park boundary.

> **<u>DEQ RESPONSE</u>:** Targets currently address macroinvertebrates and periphyton, which are critical to the food base for cold water fish. The non-toxic and percent fines conditions associated with other targets contribute to the health of the cold water fish as well as other aquatic life in these streams. These targets apply to all of Soda Butte Creek as well as other streams identified in this document. The following language has been added to the Executive Summary discussion on targets: "For aquatic life and cold water fish uses, the target goals are to provide stream conditions that can support a healthy aquatic life community based on stream capabilities. This includes the ability to support a self-sustaining fishery along with healthy macroinvertebrate and periphyton communities."

<u>COMMENT</u>: In the interest of providing the reader a comprehensive look at this complex issue, please consider adding a summary table or matrix (perhaps in the executive summary) that depicts for all three watersheds the major pollution source areas, the impairment and restoration targets, ongoing and planned restoration projects/programs and the respective responsible agencies.

> **<u>DEQ RESPONSE</u>:** Table E-1 in the Executive Summary has been expanded to address restoration strategies and other restoration plan components, and Table E-2 has been added to include a summary of the metals and pH restoration targets for all three water bodies.

<u>COMMENT</u>: The area of primary concern within the Cooke City TMDL Planning Area is delineated by Figure 1.1. It would be helpful to include a smaller scale locator map overlay so that the entire Cooke City Planning area could be viewed in context with the adjacent Boulder-Stillwater, Stillwater-Columbus, and Rock Creek-Red Lodge planning areas. There should also be some reference to the water quality conditions of those waters outside the areas of primary concern, but still within the TMDL planning area as defined by Figure 1.1.

DEQ RESPONSE: Although Figure 1-1 (now Figure E-1) was not changed, the following language has been added to the Section 1.1: "By addressing impairment conditions in these three watersheds, potentially significant impairment contributions and associated needed pollutant reductions for downstream water bodies in other TMDL planning areas are also addressed. The extent that these upstream pollutant reductions help address any downstream beneficial use support concerns will be evaluated further as restoration plans are developed for the downstream TMDL planning areas."

COMMENT: Agriculture and industry are listed among beneficial uses that are impaired for Daisy and Fisher Creeks (ref. Table 1-2). Please explain why these would be considered either present or forecast beneficial uses of water in those drainages.

DEQ RESPONSE: The following language has been added to Section 1.1.1 to address this question: "Note that a few water bodies are identified as not fully supporting the beneficial uses of agriculture and industry. State water quality standards are protective of multiple uses that always include agriculture and industry for A-1 or B-1 classified streams. The goal is to not only protect these uses within given water bodies, but to also protect these uses in downstream waters. This then ensures a healthy aquatic ecosystem while at the same time keeping pollutant levels low enough to support other existing or potential human related uses such as agriculture or industry."

COMMENT: Refer to page 1-6, second paragraph. This reads in part, "…the term restoration is used in a broad sense that includes water quality improvements …". Should restoration also refer to actions taken to reverse historic impacts that would not necessarily be corrected by measurable improvements in water quality?

DEQ RESPONSE: Language in Section 1.1.2 has been expanded as follows: "Throughout this document, the term restoration is used in a broad sense that includes water quality improvements realized through activities referred to as restoration or otherwise referred to as cleanup, remediation, treatment, or source control. These water quality improvements include a broad consideration of improvements to the chemical, physical, and/or biological components of the system. Note that water quality improvements address more than just a consideration of water column chemistry."

COMMENT: Refer to page 1-14, last paragraph. There is a discussion of water body classifications and beneficial uses. Our understanding is that when Soda Butte Creek enters Yellowstone National Park it takes on an additional "outstanding waters" classification. In addition, the Clarks Fork in Wyoming is included within the National Wild and Scenic Rivers System. Please address whether either of these stream classifications potentially have a bearing on the goals/requirements for the restoration of these impaired waters.

DEQ RESPONSE: These two additional designations have been noted in Section 1.4.1. Section 1.4.2 includes the following added language to address the Outstanding Waters designation: "Montana State law for outstanding waters (Montana Water Quality Act; Section 75-5-316) focuses on the need to prevent any new point or nonpoint sources from causing significant degradation, with focus on limiting impacts from toxic and other health related pollutants. The contaminant sources of concern, as identified within this document, are associated with existing nonpoint sources and cleanup of such sources. The outstanding resource designation appears to have no bearing on existing or proposed future activities within the Cooke City Planning Area, and restoration activities discussed within this plan are consistent with the outstanding waters designation that applies to portions of Soda Butte Creek."

The State of Wyoming and EPA were both provided the opportunity to comment and identify any deficiencies with the Clarks Fork targets in regards to protecting the National Wild and Scenic River designation. Section 3.4 includes the following added language to address the National Wild and Scenic River designation: "It appears as though the targets and TMDLs developed for the Clarks Fork River in Montana can also serve as the metals TMDLs and targets for the section of the Clarks Fork River within Wyoming. This would be protective of Wyoming's beneficial uses, satisfy Wyoming water quality standards, and be protective of the National Wild and Scenic River designation for this stream segment."

COMMENT: The points of compliance for numeric targets for the streams of interest should be presented in an additional table in Chapter 1.

DEQ RESPONSE: Figure 1-3 and several other figures identify individual monitoring sites that are later defined as measurement locations to determine progress toward meeting target goals.

COMMENT: Mention is made in several places that one of the restoration targets is restoration of biota equal to or greater than 75% of that found in a reference stream. We certainly support inclusion of biota restoration targets for all of the streams. Please explain the rationale for selection of 75%.

DEQ RESPONSE: The following language has been added to Section 1.4.2 to address this question: "Throughout this plan, several targets (reference Table E-2) are based on biota indicators being at or greater than 75% of a desired or reference condition. The 75% is directly from *Appendix A of Water Quality Assessment Process and Methods* (MDEQ, 2000). This number represents an interpretation of narrative standards, particularly those standards based on harmful conditions to aquatic life. Where any biota indicator is below 75% of reference, the stream is considered moderately impaired, and if the indicator is below 25%, the stream is considered non-supporting. Minor impairment is a situation where all biota indicators are greater that 75% of reference but still showing some negative impact(s). A stream is considered fully supporting of its beneficial uses where there is no impairment or only minor impairment. This approach recognizes that a stream where all biota indicators are at or above 75% can support a fully functioning aquatic community while also recognizing the variations in measurement methods and variations between streams that would make it difficult to justify the use of higher percentages. The approach takes into account the fact that limited minor impacts to a water body do not necessarily represent a violation of Montana's water quality standards, although they still may represent opportunities for water quality improvements. Where direct measures of biota are not available, the 75% approach is sometimes applied to habitat indicators, as is the case for the sediment targets associated with pebble counts in this plan."

<u>COMMENT</u>: Refer to page vi, third paragraph. We agree with the statement that excessive sediment accumulation in the streambed in many locations can smother aquatic life (including fish eggs), etc. Does this reference to sediment include the ferric oxide precipitate (sludge) that coats the streambed in many locations?

<u>DEQ RESPONSE</u>: Although this statement is made with sediment in mind, the sludge from metal deposits likely contributes to this condition. Satisfying both the sediment and metals targets will address both contributing conditions.

<u>COMMENT</u>: Page 2-9, section 2.2.2, 2nd paragraph, 5th sentence. Our interpretation of the data in table 2-3 is that, at a minimum, the 12.5% load attributed to the area north and west of the McLaren Mine is natural. The loads attributed to the moraine/landslide hill and to the manganese bog also are likely natural. Part of the copper load attributed to the southern and northern parts of the McLaren Mine likely is natural as well. Therefore, the range of copper loading attributable to natural background, based on table 2-3, likely ranges from 12.5% to 34.1% and possibly higher.

<u>DEQ RESPONSE</u>: The wording in this section has been modified to avoid being inconsistent with this comment, which came from the author of the study report. The 2% to 20% range has been deleted. The new wording is: "The data does not clearly distinguish between natural background loads and mining related loads. Some of the loading sources such as the moraine or landslide hill, the manganese bog, and the area north and west of the McLaren Mine may eventually prove to be indicators of natural background loads."

<u>COMMENT</u>: There are many small mining sites in the area that have not been pin pointed.

<u>DEQ RESPONSE</u>: It is acknowledged and recognized that future assessment efforts will need to address the potential that there are small mine sites that have yet to be identified and characterized. This is especially true for non-District property.

<u>COMMENTS</u>: The below subset of technical corrections were all responded to in the same manner.

- Page 1-12, 2nd paragraph. Upstream migration of fish in Miller Creek is probably prevented not only by steep gradients (as noted in the text) but also by a large waterfall about one-half mile upstream from the mouth of Miller Creek.

- Page 2-9, section 2.2.2, 1st paragraph. The text states that pH values increase consistently in Daisy Creek. On the basis of data in Nimick and Cleasby (2001), pH values are greater than 7 in the headwaters of the stream, decrease in the upper reaches where most metal loading occurs, and then start to increase continually downstream, as mentioned in the text.

- Page 2-9, section 2.2.2, 2nd paragraph, 3rd sentence. This sentence would be more accurate if 'patterns of' were inserted between 'Similar' and ''loads' at the beginning of the sentence. The actual loadings (in pounds per day) for each metal are quite different.

- Page 3-11, last paragraph, 6th line from bottom. The statement that total recoverable values are not available appears to be incorrect. The total metals data reported by Kimball et al. (1999) can be considered total recoverable concentrations, as noted in table 2 of that report.

 <u>DEQ RESPONSE</u>: All four comments were addressed by making the appropriate additions or changes to the document where noted.

<u>COMMENTS</u>: The following comments focus on monitoring of individual restoration activities.

- Refer to Figure 3-1. Some of the waste dumps circled on this map were removed and areas rehabilitated in 2001. Monitoring of revegetation and site erosion remains.

- Figure 2-3 showing a map of roads and trails is somewhat misleading, as some of the roads in the Daisy Creek drainage were obliterated/ put to bed by Crown Butte Mining Inc. These areas need evaluation as to success of stabilization in terms of sediment contribution. Perhaps more discussion of this map is in order.

 <u>DEQ RESPONSE</u>: The monitoring of revegetated areas and success of erosion control and other restoration actions are an inherent part of the New World restoration strategy. *The Long-Term Revegetation Monitoring Plan* contained within Appendix E of *the Final Overall Work Plan* (Maxim, 1999) provides specific plans for revegetated areas and also addresses reclaimed roads. The monitoring of restoration work is an important component of the performance based load allocation approach for metals and pH, where it is stated in Sections 2.3.1.3, 3.3.1.3, and 4.3.3.1 that the performance based allocation approach "includes appropriate implementation monitoring and maintenance of restoration efforts to ensure success." If significant cumulative impacts exist from reclaimed source areas such as those mentioned in the comments, then in-stream monitoring and routine water quality monitoring will detect elevated levels of pollutants.

 The road network in Figure 2-3 and similar figures for the other drainages is now referred to as the "existing and historic" road network in recognition of ongoing or completed rehabilitation efforts. These obliterated roads still present a potential accelerated pathway for pollutants due to erosion where vegetation has yet to be reestablished. They also represent a potential accelerated pathway for pollutants to ground water or surface water where an increased exposure of mineralized material exists and will likely continue to exist to some extent.

COMMENT: The following comments are closely related and addressed with one response:

- Refer to page vii, second paragraph. It is stated, "An assumption within this plan is that meeting the TMDLs based on numeric standards is expected to satisfy all other metals related targets …". Do you believe that this statement applies to heavy metal deposits that have been found in stream sediments as well?

- Please expand the discussion on the restoration target stated as, "elimination of objectionable deposits and turbidity from metal precipitates…". These deposits inhibit macro invertebrate and fish production and do not appear to flush through the system naturally.

- Section 2.3.2.1, Sediment Targets. Is it anticipated that in order to achieve these restoration targets it will require some form of stream restoration work in addition to the correction of sediment source problems? This question applies to other drainages as well.

- Please add a summary of the recently completed research at Montana State University by Marcus, Myers and Nimmo on metal contaminants of stream sediments in Soda Butte Creek and comment on its implications for present and long-term impairment.

DEQ RESPONSE: As stated in Sections 2.3.1.2 and similar sections: "As metal loading is reduced to TMDL levels, the existing fine sediments with metals contamination will likely flush through the system at high flows as they have probably been doing over the years, the difference being that they will start being replaced by fewer and cleaner fine sediment deposits." Additional targets based on macroinvertebrates, periphyton, visible streambed deposits, and non-toxic sediment conditions are included as a check on this assumption. In addition, the following recommendation is added to Section 5.5.2 (sixth bullet) to help address this concern: "As metals loading sources are removed, sediment and floodplain metals concentrations should be evaluated to determine whether or not there should be removal efforts. Any such plans should take into consideration the extent of yearly flushing associated with stream sediments and the potential for significant damage to the physical structure of the stream from removal efforts."

At this time it is envisioned that stream restoration work that includes some form of channel disturbance may only be needed in locations directly adjacent to and physically impacted (i.e. channelized) by a mine site such as the McLaren Tailings. It is recognized that elevated levels of metals in sediments and floodplains are anticipated for a potentially long period of time in Soda Butte Creek and possibly other streams in the area. Although this is not a desirable situation, mechanical removal of contaminated sediment and floodplain material can create conditions that are more harmful to aquatic life and may generally not be needed from a restoration perspective. If a given depositional area was to be independently analyzed for removal, then it may become part of the updated restoration strategy if the benefits are found to outweigh the risks, although no such locations appear to have been identified at this time for any of the drainages.

COMMENT: Refer to page 3-17. "Water treatment options" are mentioned in several places as potential restoration actions. Please explain what is meant. Would this envision a one-time treatment of impounded water or some permanent/long term chemical treatment process? Installation and operation of a long-term chemical treatment facility would incur high O&M costs and most likely is inconsistent with the undeveloped character with the area, a requirement of the consent decree. Does the discussion of the 12 major source areas on pages 17 and 18 reflect current plans and scheduling? For which of these is relevant data insufficient or nonexistent?

> **DEQ RESPONSE:** Water treatment is a potential approach to address metals sources and can refer to one time treatment, treatment as a form of mitigation during cleanup of individual sites, passive treatment, or other options that should be all be considered, at least initially, for each significant source area. The Consent Decree states "the work will be selected taking into consideration the desirability of preserving the existing undeveloped character of the District and the surrounding area". Given this goal, treatment is less likely to include a permanent long-term type of treatment involving high operation and maintenance costs and/or causing significant impacts to the undeveloped character of the area.
>
> The 12 major source areas are from the Final Overall Work Plan (Maxim, 1999), and will all be addressed via the process identified within Section 5.1 of this document. This process involves the collection and analyses of additional data as needed to make informed restoration decisions, since such data is still needed for many of the source areas. It is recognized that as New World Restoration work progresses, there may be a need for modifications to how source areas are grouped and when they are addressed as long as the modification are consistent with the work plan or approved modifications to the work plan.

COMMENT: Refer to page 4-10, fourth paragraph. This reads, "Iron has an additional target for Soda Butte Creek of no visible streambed deposits resulting from human caused conditions". Please include a discussion of the strategy for accomplishing this goal, in this section (SECTION 5.0).

> **DEQ RESPONSE:** As pointed out in Section 4.3.2: "For iron, the TMDL based on the 300 ug/l drinking water/domestic use support condition will satisfy the additional target of no visible streambed deposits associated with fine materials from human causes." The overall strategy that identifies removal of the McLaren Tailings to meet the metals targets would accomplish this goal. Once the source is removed, scour action during high flows is expected to remove any streambed staining.

COMMENT: The three comments below are closely related and addressed together.

- Refer to page 1-9, second paragraph. This paragraph briefly describes the communities within the plan area. It is important to document that there exists numerous residences in the Soda Butte Creek valley between Cooke City and Silvergate that obtain their domestic water supplies from shallow wells presumably in the Soda Butte Creek alluvium, virtually a direct connection to the surface water.

- Soda Butte Creek is more than likely impacted by the many septic tanks of the area in addition to the mining impacts. Testing is needed.

- The nutrients in the domestic water supplies are of another concern. The numerous Cooke City and Silver Gate wells need to be tested to assess the concentrations of metals and other possible contaminates, the origin of the water flows into these water supplies also needs to be determined. Most are shallow wells of 20’ to 40’. Nutrients in the water have not been tested.

  <u>DEQ RESPONSE</u>: Metals data from private wells was not incorporated. The following language addressing the metals and ground water concern was added to Section 4.1.1: “There are drinking water wells in the Cooke City area where some residents obtain their domestic water from an alluvial system that is interconnected to Soda Butte Creek flows. The retrospective analysis of previous research (Boughton, 2001) provides a summary of previous ground water work and metals sampling. Based on the previous work, metal concentrations in wells are currently below levels of concern in area ground water supplies, presumably due to high levels of dilution in the ground water system and other hydrogeologic factors.”

  Assessment results for Soda Butte Creek do not indicate a nutrient impairment problem or threat, meaning that the impacts from septic tanks are not significant enough to cause water quality problems in the surface water. Therefore, nutrient levels in ground water are outside the current scope of this restoration plan since nutrient sources, such as septic systems, are not considered an impairment cause or significant threat to Soda Butte Creek. Nevertheless, it would be prudent to test for pathogens and elevated levels of nitrate or other nutrients when doing any sampling of private wells to help address potential human health concerns associated with septic systems and to provide baseline data for future trend analyses.

<u>COMMENTS</u>: The following two comments are closely related concerning Miller Creek metals loading (Section 4.2.2).

- Page. 4-6, 4th paragraph, last sentence. This sentence states that the Black Warrior dump location ‘appears to be a potentially significant source of most of the metals of concern.’ This sentence would better reflect the results of the USGS metal-loading study if it were restated. A possible rewording would be ‘appears to be a potentially minor source of some metals of concern.’ Dissolved and total-recoverable copper concentrations remained unchanged in Miller Creek at sites upstream and downstream from the inflow that drains the Black Warrior, while concentrations of total-recoverable aluminum, iron, lead, and zinc increased. However, these increases persisted only for a short distance downstream. Although the bed-sediment samples showed that leachable-metal concentrations were elevated in the inflow draining the Black Warrior site, concentrations at the mainstem site directly downstream from the Black Warrior were only slightly higher than at the mainstem site upstream from the Black Warrior.

- Page 4-6, 5th paragraph, 1st sentence. The issues and conclusions presented in this sentence will not be addressed by the USGS metal-loading study, and therefore the reference in this sentence is not appropriate. Please delete the reference to discussions with Tom Cleasby. In addition, the sentence would better reflect metal-loading conditions in the drainage if natural background sources were mentioned. The small metal loads that enter Miller Creek during low-flow conditions likely are influenced as much, if not more, by the local geology than by mining disturbances. For example, the copper in the three inflows with elevated copper concentrations upstream from SW-2 likely comes from a combination of natural and mining-related sources. Revised text that better reflects the results of our study would be:

> Results of the USGS synoptic study indicate that metal loading to Miller Creek during low flow was relatively small and had generally minor effects on metal concentrations in Miller Creek. Substantial differences in metal loading from mine-affected areas and areas influenced by local geology could not be readily determined. During the study, total-recoverable concentrations of copper, lead, and zinc in Miller Creek were less than the chronic aquatic-life criteria in all samples with the exception of one lead value.

DEQ RESPONSE: The first sentence in the 5th paragraph on Page 4-6 has been deleted as suggested. The suggested wording has been added, and the uncertainty associated with natural background loading has been stressed. Also added is clarification that chronic standards are only occasionally exceeded during low flow conditions based on substantial monitoring results from other data sources in addition to the USGS study. It is stressed that most of the water quality concerns are associated with medium to high flow where elevated metals concentrations are consistently detected. The reference to the Black Warrior mine has been removed due to loading uncertainties associated with this specific source area.

COMMENTS: The following comments pertain to the sediment impairment determination to Soda Butte Creek.

- Further on is mention of extremely high levels of fine sediment, associated with natural conditions, entering Soda Butte Creek via Woody Creek. We know there is evidence of historic mining activity in the Woody-Republic drainage. Have you been able to separate natural from man-caused sediment production in that drainage?

- Refer to subsection 4.1.2, Sediment Impairment Decision. We disagree with the MDEQ decision and the basis for the decision to not consider suspended solids/sediment as a cause of impairment. The contention in the report seems to be that the heavy sediment load in Soda Butte Creek is all from natural sources on tributary streams. While these tributaries are a sediment source, two very significant, man caused sources exist near the McLaren Tailings, though not from the tailings impoundment itself. They are;
  a. The McLaren Mill Site is located between the highway and Soda Butte Creek. This site of about 4 acres contains unprocessed ore containing heavy concentrations of metals and pyrite spread over the area about three to six feet deep and sloping toward the creek. Erosion rills up to two feet deep are evidence of active erosion of these sediments directly into Soda Butte Creek. The 1989 superfund response action (referenced in this plan) was intended to contain the creek to its banks in a 100-year return period streamflow event, and thereby prevent washout of the tailings impoundment, not to correct the active erosion on the north side of the creek. The mill site was investigated in 1988/89 by the

Bureau of Reclamation for the EPA, reported in "Analysis of Corrective Action Alternatives for the McLaren Tailings Site Cooke City, MT", March 1989. The report states (page 17) that, "Surface runoff from this area is taking place during higher intensity precipitation events as is evidenced by the abundance of small gullies in the area. It is highly probable that substantial transport of contaminants from this area to Soda Butte Creek is occurring during periods of high surface runoff." Total concentration and water-soluble analysis are reported on seven samples showing arsenic, copper, iron and lead.

b. At the time the tailings impoundment was constructed, Soda Butte Creek was relocated into a man-made channel, having a steep gradient, on the north side of the impoundment. This deeply incised channel shows substantial evidence of active bank erosion in the vicinity of the Miller Creek confluence.

DEQ RESPONSE: As discussed in Section 4.1.2; MDEQ did not list suspended sediment as an impairment cause in Soda Butte Creek because a review of available information and onsite assessment work revealed that the majority of the sediment load is from relatively steep, erosive tributary drainages. MDEQ does acknowledged that there are undesirable mining related sources of sediment, such as those mentioned in the comments, but there is evidence that such sources are not significant enough to require a sediment TMDL for Soda Butte Creek given the very high levels of natural background sediment loading as referenced in Section 4.1.2. As further discussed at the end of Section 4.1.2, it is anticipated than any mining related restoration work associated with the McLaren Mill site and perhaps other areas of mining disturbance will need to address sediment loading since such loading represents a pathway for metals transport to Soda Butte Creek.

COMMENT: Refer to page 4-20. Consider addressing the McLaren Tailings Impoundment and the McLaren Mill Site as separate source areas as they pose unique water quality problems and could be dealt with separately in terms of restoration.

DEQ RESPONSE: The monitoring site locations, particularly SBC-2, make it difficult to address these as two separate sites from an initial source assessment and allocation perspective. Furthermore, these sites are addressed together within the *Draft Final Expanded Engineering Cost/Cost Analysis; McLaren Tailings Site, Cooke City, Montana* (Pioneer, 2002). Nevertheless, restoration can be addressed separately for these individual sources while still achieving the overall goals of this plan.

COMMENTS: The following two comments are linked closely to the threat from failure of the McLaren Tailings dam.

- To bolster the documentation supporting the timely removal (which is clearly the best “Restoration/Implementation Strategy”) of the McLaren Tailings, the Draft Plan should examine the risk of catastrophic failure which could occur as result of a high magnitude rainfall event. It appears that this discussion is within the purview of the TMDL planning process, possibly under a “margin of safety” determination.

- In addition to the discussion of the impairment of Soda Butte Creek under present conditions, the plan should acknowledge the catastrophic potential of the release of this very large tailings impoundment down the Soda Butte-Lamar River drainage. The report cited above (pages 40,41) describes a geotechnical analysis that concludes the tailings dam "exhibits only marginal static stability. It goes on to say, "…liquification of the structure is considered to be a potential threat because the dam is located in an area which has a significant probability for seismic activity".

<u>DEQ RESPONSE</u>: The following language acknowledging this additional threat has been added to Section 4.1.1: "An additional significant threat to Soda Butte Creek exists due to the McLaren Tailings dam and the potential for failure since the tailings dam is located adjacent to Soda Butte Creek where high flows can erode and saturate the dam causing an unacceptable risk of dam failure. Such a failure could cause significant damage to the physical habitat within Soda Butte Creek and release very large amounts of contaminated material that would likely deposit all along Soda Butte Creek and Lamar River valleys within Montana and within Yellowstone National Park." The resulting restoration requirement to satisfy a load allocation for the McLaren Tailings and address the associated threat from the tailings dam is further discussed in Section 4.3.3.2.1.3 where it is stated: "Given the high iron loading from the McLaren Tailings Area and the significant threat associated with a tailings dam failure, it is assumed that restoration requirements will result in the removal of these threats and will need to achieve at least a 99% reduction in total load for iron. This will then satisfy the iron load allocation….a 99% load reduction from the McLaren Tailings Area is also assumed for copper, manganese, lead, aluminum and any other metals of concern."

<u>COMMENT</u>: The following comments are closely linked to addressing sediment from forest roads and trails.

- There needs to be a mandated EIS trail and road study done by the USFS that would deal with the sediment in the streams as a result of trails and roads.

- Roads and trails are described as sources of sediment contributing to water quality impairment in all three watersheds. Our understanding is that the Gallatin National Forest is now beginning an EIS process to examine all Forest roads and trails in this area regarding their ultimate disposition; modification, maintenance, closure, removal, etc. We are told that their scoping process for that process will be during the summer, 2002. It appears that a strategy should be included in this plan to incorporate the FS road and trail planning process.

- Places in the report where mention is made of sediment source areas to be addressed under the FS project (e.g. page 2-17) it is stated that, "Roads within or accessing District Property will be evaluated…". Please check to be sure this statement is consistent with the New World Consent Decree and with the FS roads and trails planning process.

<u>DEQ RESPONSE</u>: Section 5.2.1 identifies the two categories of work as defined by the Natural Resources Working Group for the New World Mining District Response and Restoration Project. Category A is defined as "hazardous substances (i.e. mine waste) that are on District Property and non-hazardous substances (e.g. principally sediment from roads) on District Property. Work can be done prior to the receipt of the Notice of Completion from the United States Government." The New World Mining District

Response and Restoration Project will, therefore, address impacted natural resources, including sedimentation from roads. Natural resources restoration work will be included in contracts for cleanup contracts (response actions) to achieve the greatest cost efficiency and cleanup results. This work will initially be completed on District Property using the Engineering Evaluation/Cost Assessment process to determine which roads and other possible sediment sources will be addressed. Once the Notice of District Property Work Completion has been issued, any remaining cleanup funds can be used for work on non-District Property.

Section 5.2.1 also states that: "The Gallatin National Forest is now beginning a travel plan Environmental Impact Statement (EIS) process to examine all forest roads and trails in the Gallatin National Forest (including the Cooke City area). The travel plan will address the ultimate disposition; modification, maintenance, closure, removal, etc. for forest roads and trails. Preliminary information pubic meetings and scoping has started and the final EIS is scheduled for completion in the fall of 2004. The EIS will include disclosure of effects of roads on natural resources including water quality and sediment." The EIS process will then provide a linkage to restoration and sediment reduction goals and desirable water quality improvements for the Cooke City planning area, especially for those efforts that may eventually fall outside the scope of New World Restoration efforts.

COMMENTS: The following comments are associated with work potentially outside the scope of New World Mining District restoration efforts. They are all addressed by one response.

- The privately owned New World properties need to be addressed.

- I realize many of these concerns were not covered as a part of the consent decree, but the restoration of the entire district TMDL needs to take all areas into account before the overall water quality will meet specifications. The fact that many problems would "try to be taken care of", instead of mandating a remedy, does raise concerns.

- The preliminary draft report does a good job of presented the area's water quality problems on a watershed basis and establishing restoration targets. The next step is the problems on a watershed basis and establishing restoration targets. The next step is the development of restoration/implementation strategy for Daisy, Fisher, and Miller Creeks relies on the ongoing New World Mining District Response and Restoration Project to achieve the restoration targets for those watersheds. The executive summary states that the New World project is expected to "…address all significant pollutant sources of metals in the Daisy, Fisher and Miller Creek drainages." While the New World Project has identified pollutant sources within the New World mining district, the control actions only address those that are considered "District Properties". Pollutant sources on non-District private property in these drainages will not be addressed as part of the New World Mine Consent Decree. We therefore suggest that implementation strategies for those sources be developed in this document, separate from the New World actions.

- The New World Mining District appears to be fully encompassed within the Cooke City TMDL Planning Area. This preliminary plan seems fairly complete in addressing water quality impairment, pollution source areas, allocations, restoration targets and the restoration strategy for that portion of the New World Mining District that is included in the Forest Service' "New World Mining District Response and Restoration Project" (FS project). This is possible since specific program direction and funding has been available for data acquisition and planning for the FS project since the late 1990's. However, the plan is quite sketchy as it pertains to the remaining pollution source areas within the District. In order for this plan to be comprehensive in terms of total restoration of the Cooke City TMDL planning area, more specifics are needed regarding information and coordination requirements, governmental and private interests, potentially applicable programs and implementation strategies for the entire planning area.

- The Forest Service is currently working on a response action EE/CA for the Glengarry Mine area and tunnel complex and for Como Basin, all in the upper Fisher Creek drainage. A draft of the Glengarry portion is expected spring of 2002. These combined response actions, following the waste dump removals done in 2001, will cover most known metals, pH and sediment source areas from the Fisher Creek headwaters (Como Basin) to the Gold Dust Mine. This plan, then, should focus in more detail on remaining source areas in this basin for which there is no current programmatic capability.

- The Restoration Strategy section of this plan is especially important and potentially useful in presenting a comprehensive strategy for the eventual water quality restoration of the entire New World District. Considerable baseline data acquisition and planning has been completed or underway for the Forest Service District Properties. Other contaminant load sources not being addressed under the FS project are located on private property or other National Forest lands. Some of these source areas have investigation and planning work underway (McLaren Tailings/Mill Site and New Republic Smelter) while little is known about others.

- We realize the MTDEQ has long recognized that the McLaren Tailings should be removed in order to satisfy water quality standards. This document presents specific pollutant targets that would support removal. The New World Mine Restoration effort will not address the McLaren Tailings until all other district restoration activities have been addressed (5.2). The time line on completion may extend for years. In the meantime, the McLaren Tailing remain in place. We are aware of the discussions between the MTDEQ and the US Forest Service about a number of strategies, including removal of all or part of the McLaren Tailings to the NW on-site repository, or other USFS managed lands. Removal during the New World Project period would be the most efficient and effective solution to the majority of the Soda Butte Creek water quality problems. Funding strategies outside the New World account should be explored. To date, a logical solution to this serious problem appears unresolvable due to federal public land policy issues related to waste disposal. The MTDEQ, Abandoned Mines Program is about to release a draft Engineering Evaluation and Cost Analysis that presents other possible solutions. The TMDL planning team should review this document and add to the reference section.

- Montana Department on Environmental Quality's excellent brochure, *Introduction to TMDLs & Water Quality Restoration Planning,* state, "to meet EPA requirements it is necessary to develop a conceptual restoration/implementation strategy to demonstrate that, when implemented, the plan will result in achieving the proposed TMDL and restoration targets." We are disappointed that restoration/implementation strategies were not developed for Soda Butte Creek. Presumably, this is because, as the brochure states, "…there is a lack of firm commitments to address other sources of metals such as the McLaren Tailings" and "additional data is also needed along Soda Butte Creek and in key tributaries to Soda Butte Creek to identify and characterize sources of metal loads to Soda Butte Creek."

- Funding and additional data are needed, but this should not delay planning for addressing known significant pollution sources such as the McLaren Tailings and the Great Republic Smelter Site. The Montana Department of Environmental Quality (DEQ) Mine Waste Cleanup Bureau has prepared a reclamation plan for the Republic smelter site which is listed in the references section but not discussed in the restoration strategy section. The Bureau is also in the process of preparing an Engineering Evaluation /Cost Analysis for the McLaren Tailings Site. This water quality restoration plan should include and evaluate both proposals for their potential to attain the required loading reductions that are necessary from these facilities to meet water quality standards in Soda Butte Creek.

- Finally, we suggest a "road map" be included for implementing restoration strategies for each non-New World district property to assist property owners who wish to voluntarily undertake a cleanup of a pollutant source. Such guidance would greatly assist property owners to understand how they could do it; which Best Management Practices would be applicable; which programs could help with funding; which permits would be required; and which agencies would need to be involved. The more we can do to assist voluntary restoration, the better our chances for success.

DEQ RESPONSE: Much of the document has been rewritten and significant language has been added to better define the strategy for non-District Property and how it fits into New World Mining District restoration efforts. This includes additional language and significant changes to the performance based load allocation sections (Sections 2.3.1.3, 3.3.1.3, and 4.3.3.1) to better address non-District Property considerations and how they may or may not be addressed by New World Mining District efforts depending on whether the necessary restoration work falls within Category A or Category B. Section 5.2 *Additional Restoration Strategy Considerations by Drainage Area* is a completely rewritten section to better address both District and non-District Property consideration and does reference the *Draft Final Expanded Engineering Evaluation/Cost Analysis; McLaren Tailings Site, Cooke City, Montana* (Pioneer, 2002).

Section 5.3 *Restoration Approaches for Metals Sources*; and Appendix H: *Cleanup/Restoration and Funding Options for Mine Operations or Other Sources of Metals Contamination* are both new additions to help provide guidance and an overall road map for pursuing sources of metals contamination throughout the Cooke City TMDL Planning Area. Appendix H also discusses funding possibilities and both Section 5.3 and Appendix H discuss interagency and stakeholder coordination needs and responsibilities. Many of the previous and newly added bullets under Section 5.5 *Monitoring Strategy* focus on the need to characterize non-District property metals sources in a coordinated manner.

COMMENTS: The following comments are associated with agency coordination and implementation. Some are specific to coordination with the state of Wyoming.

- With so many private landowners and agencies, state and national, such as the U.S. Forest Service, Yellowstone National Park, U.S. Geological Survey, Montana Department of Environmental Quality, Montana Fish Wildlife, and Parks, and the state of Wyoming, involved; I would question the possibility of it happening unless it is mandated. Coordination between these agencies is a must if it is to be successful. I am bothered by the fact that many problems "might" be addressed.

- There are numerous governmental and private entities that have some interest and/or responsibility for portions of the total water pollution problem that exists in the New World Mining District; the Forest Service (on their District Properties and other lands), the EPA (regulatory oversight), the National Park Service (recipients of pollution impacts), the State of Wyoming, private landowners, Montana Fish, Wildlife and Parks, US Geological Survey and various interest groups. This paints a very complex picture of divided responsibilities and numerous programs that must somehow be coordinated to ensure a comprehensive final result.

- Refer to page 1-1, first paragraph. The goal of this plan is stated as, "The overall goal is to identify an approach to improve water quality to a level where beneficial uses are restored for all impaired water bodies in the Cooke City TMDL Planning Area and ensure that Montana water quality standards are not violated". That is certainly a laudable goal and one we would support. However, reaching this goal may not be possible without close cooperation with all other governmental entities having responsibilities in this area, including the State of Wyoming. We encourage you to consider some organizational framework that fosters this coordination among the agencies and concerned public. At the meeting on Jan. 15th we discussed the idea of forming a "watershed group" to coordinate the many contributions toward this overall goal. We would be interested in exploring these ideas further.

- It is possible the state of Wyoming might not do a TMDL?

- Please add a discussion of MDEQ strategy for coordination with Wyoming. Overlapping interests seem to include Soda Butte Creek tributaries (possibly impaired) that originate in WY and Soda Butte Creek and the Clarks Fork (presently impaired) flowing into Wyoming. We presume Wyoming has responsibilities similar to those of Montana under section 303(d). Does the EPA have an interstate coordination role in this process?

  DEQ RESPONSE: The New World restoration efforts are mandated via the Consent Decree, and there is significant coordination among the agencies and entities identified. As discussed within Sections 5.2 and 5.3 as well as Appendix H, there are significant sources that will probably need to be addressed by other methods beyond the scope of New World restoration. Some of these sources do not have mandates or guaranteed funding, and a coordinated approach to identify, prioritize, and perform restoration activities on these sources is important. Some of this work has already occurred within the DEQ Abandoned Mines Program. Where additional opportunities for restoration occur, such as is the case for the Republic Mine and Smelter Site and the McLaren Tailings, the goal will be to ensure the work is coordinated among the various state and federal agencies and other stakeholders. This coordination often occurs in the form of identifying restoration options and public comment on proposed options and detailed plans. Section 5.3 includes language that stresses the need for coordination and also recognizes the potential benefits, such as stakeholder coordination, that can be provided by a watershed group.

Coordination with Wyoming will be especially important for Soda Butte tributary work, and EPA may have a role in facilitating this effort, as mentioned in Section 5.3. This is particularly important for any efforts to identify and remediate metal contaminant sources to stream segments located within Wyoming. As discussed in Section 3.4, Wyoming water quality standards are based on dissolved versus total recoverable, meaning that some streams which originate in Wyoming may not be identified as impaired water bodies in Wyoming because elevated levels of metals may be in the total recoverable form. Section 3.4 also points out that Montana is required to pay attention to Wyoming standards and that by meeting the standards in streams located in Montana, we will also be meeting the Wyoming standards where streams flow from Montana into Wyoming.

It is acknowledged that all restoration planning, particularly planning outside the scope of New World, will need to occur in a manner that ensures a comprehensive final result, which is part of the implementation strategy defined throughout Section 5.0. Again, formation of a watershed group can be an effective approach to assist with this overall coordination.

COMMENT: Soda Butte restoration planning is acknowledged to be different than the other water bodies (5.4). It appears that the most significant sources of pollution, the McLaren Tailings, is destined to fall into Target Category #3 (5.3): “The target is not achieved and will not likely be achieved due in part to a failure to implement all applicable restoration efforts in a manner that is considered sufficient application of all reasonable land, soil, and water conversation practices.”

DEQ RESPONSE: Target Category #3 is intended to be a temporary condition that forces additional restoration work as needed to ensure that all targets eventually fall into Categories #1 or #2, and therefore represent conditions where Montana Water Quality Standards are satisfied. It is not appropriate to apply these target categories to a specific source, such as the McLaren Tailings. They instead apply to the pollutants in the stream, such as iron or manganese. It is acknowledged within Section 5.4 (formally Section 5.3) that the McLaren Tailings, as well as other potentially significant sources, could end up being the primary reason that one or more targets fall into Category #3 for a substantial amount of time due to funding limitations and firm restoration commitments.

COMMENT: We agree with the adaptive management approach described, which weighs restoration results against, "sufficient application of all reasonable land, soil and water conservation practices". This approach, if properly employed, should avoid expenditure of an inordinate amount of resources on one source area for little or no improvement, while other source areas remain untreated. The public should have involvement in the decisions that place source areas within the three categories described.

<u>DEQ RESPONSE</u>: Agreed, and language has been added to Sections 5.4 and 6.0 to stress the fact that the public has involvement during key phases of New World Mining District restoration efforts as well as involvement with restoration planning efforts outside the scope of New World. The specific restoration approaches, which take public comment into account, will help determine "sufficient application of all reasonable land, soil and water conservation practices". Furthermore, the public is involved with any modifications to water quality standards, which may be the situation prior to any final determination involving the use of Target Category #2. The public will also have opportunity to comment on modifications to future 303(d) lists and modifications to this water quality restoration plan which could include target determinations as defined in Section 5.4. Section 6.0 also includes the following language that supports public involvement and how it can be obtained for target category determinations: “Public comment on target categories could be facilitated via comment on New World Mining district restoration plans, agency decisions associated with temporary standards or water body classifications, and/or comment on restoration plans outside the context of New World Mining project efforts.”

<u>COMMENT</u>: We note that the Forest Service' 2002 McLaren Pit Response Action EE/CA is directed to the major sources in this drainage, where temporary water quality standards are in place. The FS plan calls for water quality monitoring during construction and long-term, from which to judge results. Does MDEQ believe that this planned response action is sufficiently comprehensive as to address all of the water quality restoration targets for this basin? If not, what actions will remain?

<u>DEQ RESPONSE</u>: The monitoring proposed by the Forest Service addresses the majority of monitoring needed to track progress on a yearly basis as discussed within Section 5.5.1. Section 5.5.3 identifies additional monitoring, such as pebble counts, that DEQ will likely need to do in order to evaluate progress toward meeting restoration targets. Sections 5.5.1 and 5.5.2 identify some additional monitoring recommendations and needs for long-term and source assessment monitoring purposes, some of which would apply to the Forest Service’s New World Restoration efforts.

<u>COMMENT</u>: Refer to Section 2.2.2, Metals and pH Source Assessment. The report correctly points outs that higher concentrations of metals occur during base flow periods, suggesting high ground water contributions. Our hope and expectation is that the pending response action that is designed to consolidate the mine waste materials and isolate them from direct precipitation and runoff infiltration will eventually reduce the loading and acidity from groundwater discharges to Daisy Creek. Long term monitoring will be needed to detect any resulting improvements.

<u>DEQ RESPONSE</u>: Much of the District monitoring addresses these concerns over the next several years, although there appears to be uncertainty associated with monitoring beyond the temporary standards period and beyond completion of Consent Decree actions. The MDEQ Monitoring and Data Management Bureau also performs monitoring to track progress toward meeting targets at least once every five years, which would continue beyond District cleanup as needed. Even with the MDEQ target evaluation monitoring, there may still be a need for additional monitoring to evaluate success of specific restoration actions. The following language addressing the need for continued long-term monitoring has been added to Section 5.5.1: "The New World Mining District Monitoring Plan extends through the temporary standards period of 2014. Plans need to be put in place to extend the monitoring as needed beyond this date for select parameters starting 2015. This should include monitoring at established stream locations as well as monitoring the success of individual restoration sites including monitoring for potential leakage from any repository site(s)."

<u>COMMENTS</u>: The following two comments are closely related.

- Refer to page 3-9. The acknowledged unknown regarding copper loading to the Clarks Fork from Lady of the Lake Creek should be reflected in the data acquisition strategy in Section 5.0.

- The narrative and tables in previous sections acknowledge a need for additional data (Soda Butte Cr. tributaries, Lady of the Lake Creek, Miller Creek) in order to present a complete picture of load allocations and source contributions. Please consider adding a subsection on specific data needs and a strategy for acquiring this data, to this section.

<u>DEQ RESPONSE</u>: Sections 3.2.2, 3.4, and 5.5.2 include recommendations for source characterization. Several of the Section 5.5.2 bulleted recommendations specifically address the above comments. Appendix H provides some potential strategies for pursuing restoration and associated characterization, as well as funding considerations.

<u>COMMENT</u>: Monitoring to be done in conjunction with the FS project should include the condition of the streambed sediments, size gradation (pebble counts), presence of precipitate sludge and the presence of aquatic organisms as described in this plan. Have these requirements been discussed with the FS and is MDEQ satisfied their monitoring protocols in this regard?

<u>DEQ RESPONSE:</u> This type of monitoring (reference Section 5.5.3) is generally performed by DEQ as part of their five-year target evaluations, and also as a part of the efforts to further define reference stream conditions for the Fisher Creek sediment target. This does not preclude using data acquired by the FS or other qualified entities. Although most of the monitoring activities, such as those associated with pebble counts and aquatic organisms, are based on standard protocols, it is acknowledged that coordination will be important where different entities are collecting similar data types.

<u>COMMENT</u>: We invite MDEQ to make a return visit to Cooke City this summer, when more of the seasonal residents are available to participate, to give a presentation on a revised version of this plan. BA would be pleased to assist with arrangements and local publicity.

<u>DEQ RESPONSE</u>: MDEQ will continue to work with local stakeholders on various outreach efforts associated with this plan and implementation of the plan and appreciates offers of assistance. Any outreach and implementation will need to be balanced with requirements to develop and implement similar restoration plans and associated TMDLs across the state.

<u>COMMENTS</u>: The following comments are acknowledged, with no response needed.

- The document points out that "…New World Mining District Response and Restoration activities are expected to address all significant pollutant sources of metals in the Daisy, Fisher, and Miller Creek drainages". These activities are related to work on "District Properties" as defined in the "Consent Decree" which is the legal guidance for the work being done by the US Forest Service. The TMDL document content and data greatly benefits from the New World Work Plan and these activities. Conversely, the New World Restoration Project now has clearer water quality goals and guidance. This is especially true when efforts turn to addressing sediment loading sources that may or may not be mineralized, but can be ameliorated through best management practices including road closure.

- The preparation of a comprehensive water quality restoration plan is an important step towards our shared goal of improving the area's water quality to a level where Montana's water quality and drinking water standards are met and insuring that park resources and values, including aquatic life, are not impaired.

- We agree with your description of the present condition of impairment and that TMDL development is not needed for the Stillwater River above Daisy Creek.

- Refer to page 3-5, Impairment Conditions Associated with Sediment. We agree with your basis for adding a sediment target TMDL for Fisher Creek.

- We believe that this Water Quality Restoration Plan could be a most useful tool for guiding the comprehensive restoration of the entire TMDL planning area, and encourage MDEQ to continue development of it. BA stands ready to assist from our perspective as a representative of local interests.

- We recognize that this 303(d) process could be the much-needed vehicle for comprehensively addressing water quality restoration needs of the entire New World Mining District. BA is interested in working with the MDEQ to help ensure that this be a meaningful process toward achieving our shared goals.

- Refer to page 2-19, third full paragraph, last sentence. This text appears to suggest an adaptive strategy be applied to sediment targets following implementation of reasonable control measures. We agree with that approach, especially in view of the rather crude estimates that are characteristic of sediment yield models. Preference would be to direct available program funding to known contaminant source areas rather than expend large sums attempting to achieve unrealistic levels of sediment yield reduction.